Gary Rice
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V=SEE CHANGE NOTICE
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OF BOOK

INSTRUCTION MANUAL

MODEL 167

AUTO-PROBE™
DIGITAL MULTIMETER

KEITHLEY INSTRUMENTS

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the Cleveland factory, DDD 216-248-0400. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments maintains a complete repair service and standards laboratory in Cleveland, and has an authorized field repair facility in Los Angeles and in all countries outside the United States having Keithley field representatives.

To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

INSTRUCTION MANUAL

MODEL 167 AUTO-PROBE™
DIGITAL MULTIMETER

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SPECIFICATIONS

AS AN AUTORANGING DC VOLTMETER
RANGE: ± 1 millivolt per digit to ±1000 volts.
ACCURACY: ±0.2% of reading ±1 digit
INPUT IMPEDANCE: 55 megohms shunted by approximately 220 picofarads.
NMRR: Greater than 55 dB above 50 Hz.

AS AN AUTORANGING AC VOLTMETER
RANGE: 1 millivolt per digit to 500 volts rms.
ACCURACY: Up to 200 volts; ±1% of reading ±2 digits, 20 Hz to 10 kHz, ±2% of reading ±4 digits to 20 kHz. 200 volts to 500 volts; ±2% of reading ±2 digits, 20 Hz to 1 kHz, ±5% of reading ±4 digits to 20 kHz.
INPUT IMPEDANCE: 50 megohms shunted by approximately 220 picofarads.

AS AN AUTORANGING OHMMETER
RANGE: 1 ohm per digit to 20 megohms.
ACCURACY: ±0.3% of reading ±1 digit ±1 ohm.
TEST CONDITIONS: Current; 1 milliampere to 0.1 microampere depending on range. Voltage; 1 volt at 1000 digits, 9 volts maximum into an open circuit.

GENERAL
READING TIME: Less than 2 seconds to rated accuracy.
DISPLAY: 3 1/2 digits, appropriate decimal position, polarity indication and indication of function (DC, AC, kΩ, MΩ) all on probe. Upranges at 2000, downranges at 0189.
POLARITY: Automatic
RANGING: Fully automatic on each function.
OVERLOAD INDICATION: Display blinks when beyond specified maximum range.
MAXIMUM OVERLOAD: 1200 volts dc + peak ac on voltage ranges. 130 volts dc + rms ac on ohms.
STABILITY: ±0.02% of reading ±0.2 digit per °C. Calibrated @ 23°C.
ENVIRONMENT: Operating 0°C to 50°C. 0% to 70% Relative Humidity up to 35°C. Storage -25°C to +65°C.
POWER:

Supplied with Model	6 "D" Cells for internal mounting (Any type useable)	Life with continuous operation	Life with push-to-read switch*
167	Alkaline	20 hours typ.	3 months typ.
167/1671	Nickel-Cadmium	12 hours ** per charge typ.	1 month per charge typ.

*Holding probe turns instrument on. Instant warmup permits final reading within 2 seconds.
**Recharging of internal Nickel-Cadmium batteries and/or line operation is provided by power source included in Model 1671.

BATTERY TEST: Test point for measuring battery voltage with instrument itself provides indication of battery condition.
CONNECTORS: Probe tip and alligator ground clip. When probe is stored in instrument, banana jacks.
DIMENSIONS, WEIGHT: Probe; 7-3/8 in. x 5/8 in. (188 x 15mm), 1-1/4 in. x 3/4 in. (31 x 18mm) display area, 4-1/2 ft. (1500mm) cable. Electronics Pack; 3 in. high x 6-3/4 in. wide x 10-1/2 in. deep (75 x 170 x 265mm), net weight (with Alkaline cells) 4 pounds (1,9 kg).
ACCESSORIES FURNISHED: Ground lead, attached probe.

SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION. The Model 167 is a compact, versatile, autoranging digital multimeter useful for measurement of voltage, resistance, and current. The Model 167 indicates ac volts from 1 mV to 500 volts, dc volts from 1 mV to 1000 volts, and resistance from 1Ω to 20 MΩ. Current measurements also can be made from0.1 μA to 2 amperes with the accessory Model 1673 Current Shunt.

1-2. WARRANTY INFORMATION. The warranty is given on the inside front cover of the manual. If there is a need for service, fill out the Service Form supplied at the back of the manual.

1-3. CHANGE NOTICE. If there are any improvements or changes to the instrument not incorporated into the manual these will be explained on a yellow Change Notice attached to the inside back cover.

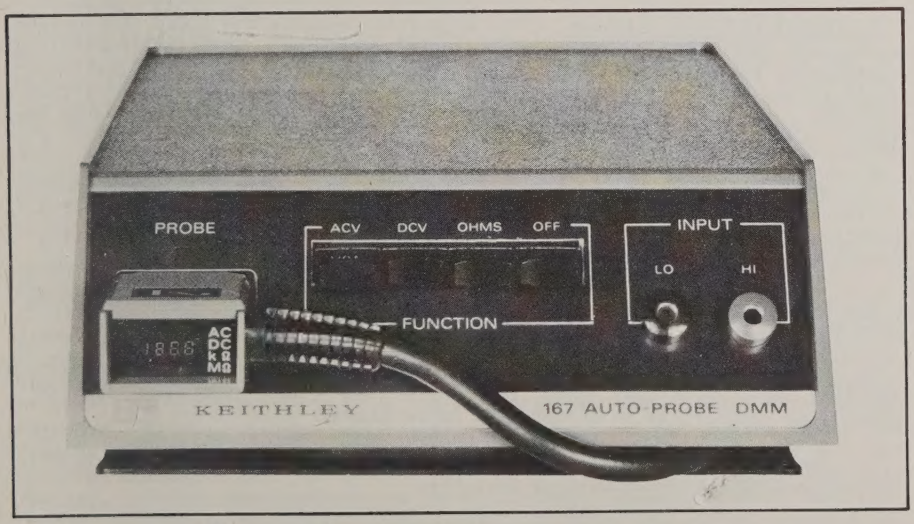


FIGURE 1. Front Panel With Probe Installed.

1-4. APPLICATIONS.

a. Probe Measurements. The Model 167 is useful for electrical measurements wherever a portable battery-operated instrument is needed. Since the digital display is in the probe, measurements can be quickly and easily made by simply moving the probe from point-to-point such as when servicing electrical circuits.

b. Bench Measurements. The Model 167 is also useful as a bench operated multimeter with the probe installed in the front panel. The front panel terminals are used to make all connections for normal multimeter operation.

1-5. ACCESSORIES.

a. Model 1671 Rechargeable Battery Kit. This accessory includes a set of six nickel-cadmium batteries and line-operated Recharger. The Recharger cable mates with the rear panel "AUXILIARY POWER" receptacle on the Model 167. The Model 167 can be operated while the Recharger is connected to line power. The Recharger provides greater than 10^8 ohms insulation resistance between LO and power ground with 500 volts maximum common mode voltage.

b. Model 1672 Line Adapter. This accessory converts the Model 167 to line operation. The Adapter cable mates with the rear panel "AUXILIARY POWER" receptacle on the Model 167. The Model 167 automatically switches to battery power if the line voltage is interrupted. The Adapter provides greater than 10^8 ohms insulation resistance between LO and power ground with 500 volts maximum common mode voltage.

c. Model 1673 Current Shunt. This accessory is a current shunt which adds to the Model 167 the capability to measure current from 0.1 μA to 2 amperes. Accuracy of the shunt resistors is ±0.3%. The resistors are switch selected in decade steps from 1 ohm to 10 kilohms.

d. Model 1674 Carrying Case. This accessory is a rugged leather carrying case with an adjustable shoulder strap and belt loop.

e. Model 1677 Power Cable. This accessory is a power cable which mates with the rear panel "AUXILIARY POWER" receptacle. The 4 foot long cable permits convenient connections to an external power source.

f. Model 1678 Rechargeable Battery Set. This accessory is a set of six nickel-cadmium batteries without Recharger.

g. Model 1679 Alkaline Battery Set. This accessory is a set of six non-rechargeable alkaline cells.

SECTION 2. INITIAL PREPARATION

2-1. GENERAL. This section describes procedures for incoming inspection and preparation for use.

2-2. INSPECTION. The Model 167 was carefully inspected both mechanically and electrically before shipment. Upon receiving the instrument check for any obvious damage which may have occurred during transit. Report any damages to the shipping agent. To verify the electrical specifications test the instrument using the Performance Check procedure in Section 5.

2-3. PREPARATION FOR USE. The Model 167 is shipped ready-to-use with six alkaline batteries installed in the battery compartment. The probe is installed in the front panel with the cable wrapped around the base of the chassis. The ground lead is stored in the opening on the bottom of the instrument.

a. Battery Operation Using Alkaline Cells. The Model 167 is useable for up to 20 hours of continuous operation from a set of six alkaline batteries. The battery condition may be checked at any time using the probe for a self-test. To test the batteries, remove the probe from the front panel, depress the "DCV" pushbutton and "push-to-read" switch along the top of the probe. Touch probe tip to the rear panel "BATTERY TEST" terminal and read the display. The reading should be greater than 6 volts for satisfactory battery condition. If the Model 167 fails to turn on, check for proper installation of the batteries as shown in Figure 9. If the voltage is too low, replace with new batteries as explained in paragraph 3-8c.

b. Battery Operation Using Nickel-Cadmium Cells. The Model 167 can also be powered by rechargeable nickel-cadmium batteries for up to 12 hours continuous operation. The battery condition may be checked at any time using the probe for a self-test. To test the batteries, remove the probe from the front panel, depress the "DCV" pushbutton and "push-to-read" switch along the top of the probe. Touch probe tip to the rear panel "BATTERY TEST" terminal and read the display. The reading should be greater than 7 volts for satisfactory battery condition. If the Model 167 fails to turn on, check for proper installation as shown in Figure 9. If the batteries are installed properly and the voltage is too low, connect the accessory Model 1671 Recharger as described in paragraph 3-8d and recharge the batteries. To ensure that the nickel-cadmium batteries are fully charged, recharge the batteries at least 16 hours. Since the Model 1671 Recharger is useable as a line power adapter, the Model 167 can be operated continuously even while recharging the batteries.

c. Line Operation Using the Model 1672. The Model 1672 converts the Model 167 to line operation when connected as described in paragraph 3-9.

SECTION 3. OPERATING INSTRUCTIONS

3-1. GENERAL. This section describes the procedures for operating the Model 167 as a voltmeter, ohmmeter, and ammeter.

3-2. TURN-ON PROCEDURE. When the probe is installed in the front panel the Model 167 can be turned on by depressing any one of the front panel pushbuttons identified as "ACV", "DCV", or "OHMS". When the probe is removed from the front panel the "push-to-read" bar along the top of the probe must be depressed and held in this position to turn on the instrument. The display in the probe is lighted whenever the instrument is turned on and therefore serves as a "power on" indication. When the "push-to-read" bar on the probe is released the instrument will be turned off thereby conserving battery power. When the probe is installed in the front panel the Model 167 will be turned on continuously unless the front panel "OFF" pushbutton is depressed.

3-3. CONNECTIONS. The Model 167 has two front panel terminals identified as "HI" (red) and "LO" (black). These terminals mate with "banana" plugs similar to Keithley part no. BG-5. The probe tip can also be used for connections to "HI" instead of the front panel "HI" terminal.

a. Probe Measurements. The Model 167 probe can be used for in-circuit measurements with the convenience of a display visible right at the point of measurement. To make a measurement, remove the probe from the front panel, unwind the probe cable, select the desired FUNCTION, depress the "push-to-read" bar, and use the probe and front panel "LO" terminal for input connections. When the probe is used for measurements the front panel "HI" terminal is automatically disconnected. The accessory ground lead, which is stored in the bottom of the instrument, may be used for connection to the "LO" terminal.

b. Bench Measurements. The Model 167 can be used for making measurements with both front panel "HI" and "LO" terminals connected to the input. To make a measurement, install the probe in the front panel and select the desired FUNCTION. The front panel "HI" is activated only when the probe is installed in the front panel opening designated "PROBE". The accessory ground lead may be used for connection to the "LO" terminal. A similar lead may be used for connection to the "HI" terminal. Since the front panel terminal spacing is 3/4", a dual "banana" plug (such as Keithley part BG-7) may be used for quick connections to both terminals.

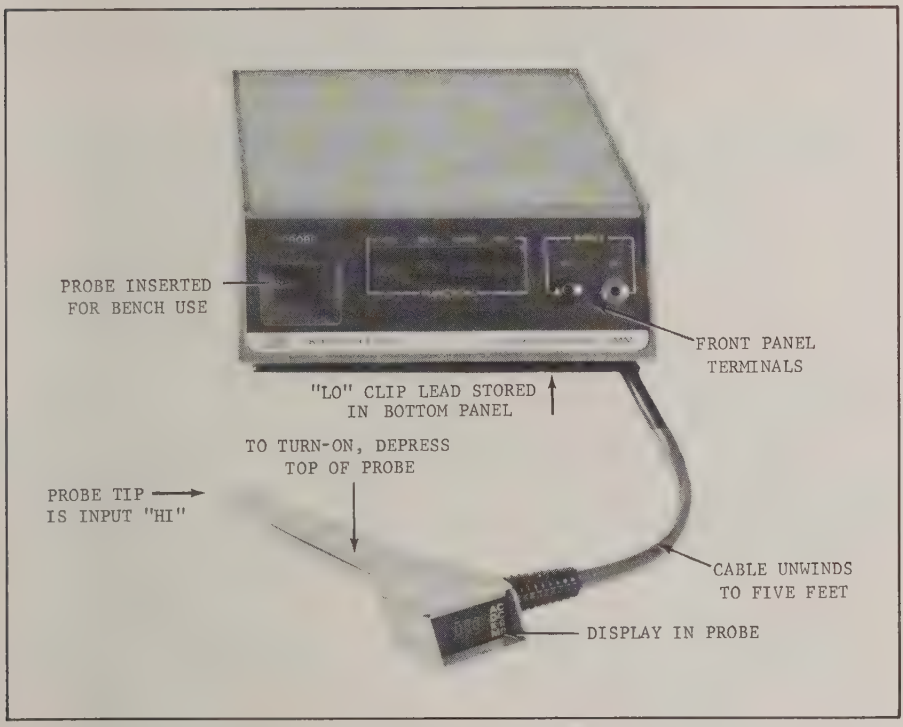


FIGURE 2. Front Panel With Probe Removed.

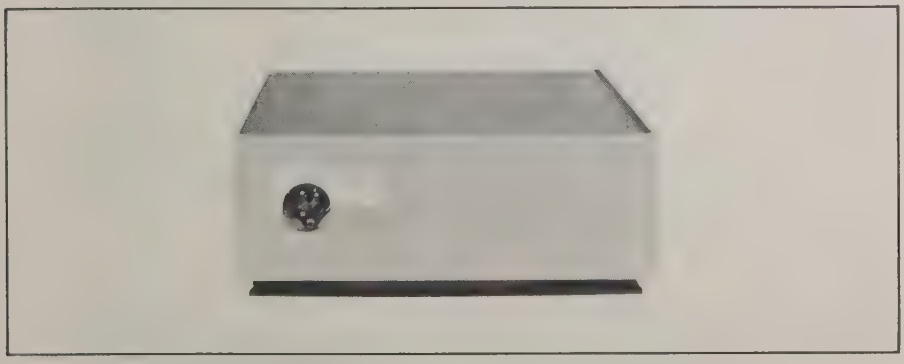


FIGURE 3. Rear Panel, Auxiliary Power Receptacle.

3-4. FUNCTION SELECTION. Four front panel pushbuttons are used for selection of ac volts (ACV), dc volts (DCV), resistance (OHMS), or power off (OFF).

NOTE

When any one pushbutton is depressed, all three remaining buttons are released. However, a condition may exist where all four buttons are released. This condition is a non-useable mode where the input "HI" is disconnected and the display indicates 0-0-0 kΩ. If this occurs, depress the desired function.

3-5. OPERATION AS A VOLTMETER. The Model 167 can be used to measure ac or dc voltage from 1 mV to 500 Vac or to 1000 Vdc.

a. DCV Operation. The Model 167 automatically indicates dc voltages from 1 mV to 999V with polarity automatically indicated.

1. Measurement Procedure. Depress the "DCV" pushbutton to select dc voltage measurements. Make input connections using the probe or front panel "HI" and "LO" terminals as described in paragraph 3-3. Depress the "push-to-read" switch to turn-on the display. The digital display is described fully in Figure 8 and the caption below the illustration.

NOTE

The Model 167 automatically ranges to the proper range with decimal point and polarity automatically indicated. A lighted "minus" sign is displayed for negative dc voltages. A positive polarity is not indicated but is implied when the "minus" sign is turned off.

2. Input Impedance. The input resistance is 55 megohms over the entire voltage range. The shunt capacitance is approximately 220 picofarads. The high input resistance allows measurements to be made without significant circuit loading errors.

3. Accuracy. The Model 167 accuracy is specified as ±0.2% of reading ±1 digit over the entire voltage range.

4. Maximum Input. The maximum input voltage which can be applied is specified as 1200V (dc + peak ac). The Model 167 display flashes when the input exceeds ±999 volts although the reading will be displayed up to the maximum dc input.

b. ACV Operation. The Model 167 automatically indicates ac voltages from 1 mV to 499 volts over a range of frequencies from 20 Hz to 20 kHz.

1. Measurement Procedure. Depress the "ACV" pushbutton to select ac voltage measurements. Make input connections using the probe or front panel "HI" and "LO" terminals as described in paragraph 3-3. Depress the "push-to-read" switch to turn-on the display. The digital display is described fully in Figure 8 and the caption below the illustration.

NOTE

The Model 167 automatically ranges to the proper range with decimal point automatically indicated.

2. Input Impedance. The input resistance is 50 megohms over the entire voltage range. The shunt capacitance is approximately 220 picofarads.

3. Accuracy. The Model 167 is an average-reading meter which is calibrated in terms of the rms value of a sine wave. The basic accuracy is ± 1 % of reading $\pm$ 2 digits (up to 200V, 20 Hz to 10 kHz).

4. Maximum Input. The maximum input voltage which can be applied is specified as 1200V (dc + peak ac). The Model 167 display flashes when the input exceeds 499 volts rms although the reading will be displayed up to the maximum allowable input.

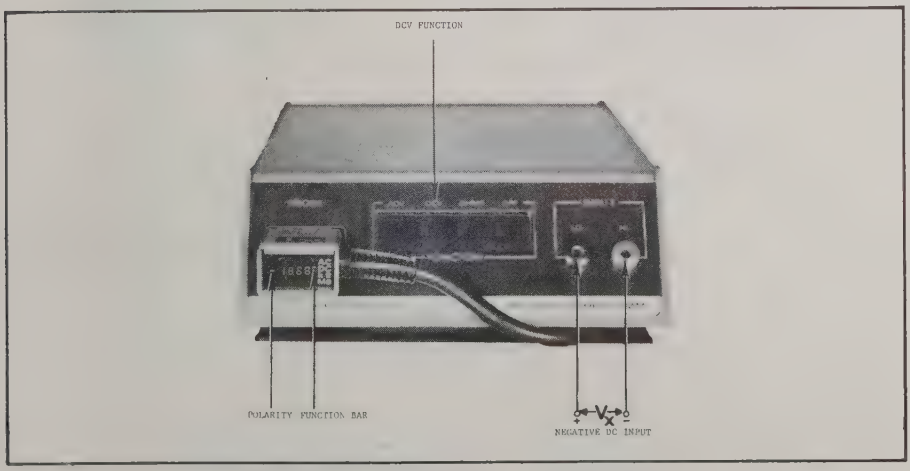


FIGURE 4. Operation As A Voltmeter.

3-6. OPERATION AS AN OHMMETER. The Model 167 can be used to measure resistance from 1 ohm up to 20 megohms.

a. Measurement Procedure. Depress the "OHMS" pushbutton to select resistance measurements. Make input connections using the probe or front panel "HI" and "LO" terminals as described in paragraph 3-3. Depress the "push-to-read" switch to turn-on the display. The digital display is described fully in Figure 8 and the caption below the illustration.

NOTE

The Model 167 automatically ranges to the proper range with the decimal point indicated automatically. The appropriate range symbol (either kΩ or MΩ) is indicated automatically by the "lighted bar" adjacent to either the kΩ or MΩ symbol.

b. Test Current. The Model 167 delivers a test current from 0.09 μA to 0.9 mA as shown in Table 3-4. The "LO" terminal is positive with respect to the "HI" terminal. The terminal voltage is approximately 1.8 volts for a maximum reading on any range. The maximum open circuit voltage is approximately 9 volts in series with 50 megohms.

c. Accuracy. The Model 167 accuracy is specified as ±0.3% of reading ±1 digit ±1 ohm.

d. Maximum Input. The maximum input voltage which can be applied to the input when in the "OHMS" mode is 130V dc or ac rms. If this voltage is exceeded and connected for more than a few seconds, overheating of the range resistors may occur with subsequent change to the accuracy.

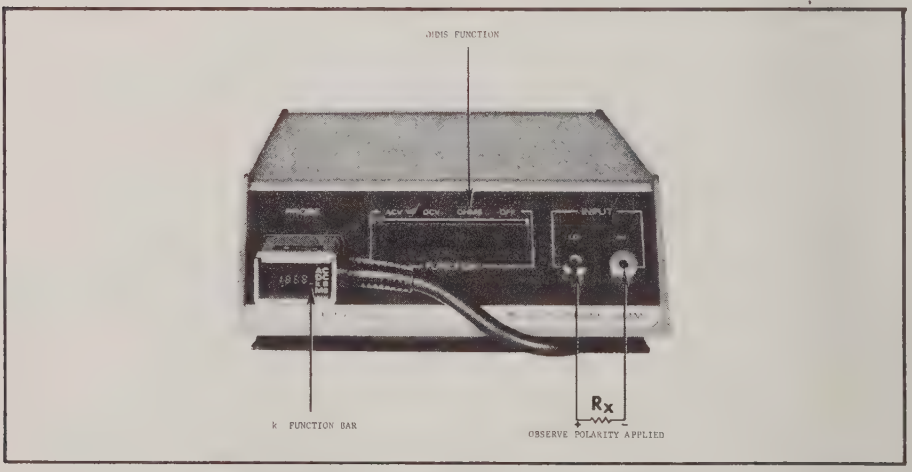


FIGURE 5. Operation As An Ohmmeter.

e. Diode Test. When measuring the forward resistance of a semiconductor junction (such as a diode) connections should be made as shown in Figure 6a. Two different readings can be displayed depending on the manner in which the measurement is made. The reverse resistance for a silicon junction should indicate greater than 20 megohms when connected as shown in Figure 6b.

1. Short Circuit Technique. Connect the diode and shorting switch (or shorted leads) as shown in Figure 6a. To make a reading, remove the short across the terminals. The display should indicate less than 1000 ohms for for a typical silicon diode. This technique is recommended when checking diode conduction.

2. Open Circuit Technique. Connect the diode as above except do not short the input terminals. The display should indicate less than 5 megohms when making a forward resistance measurement of a silicon diode.

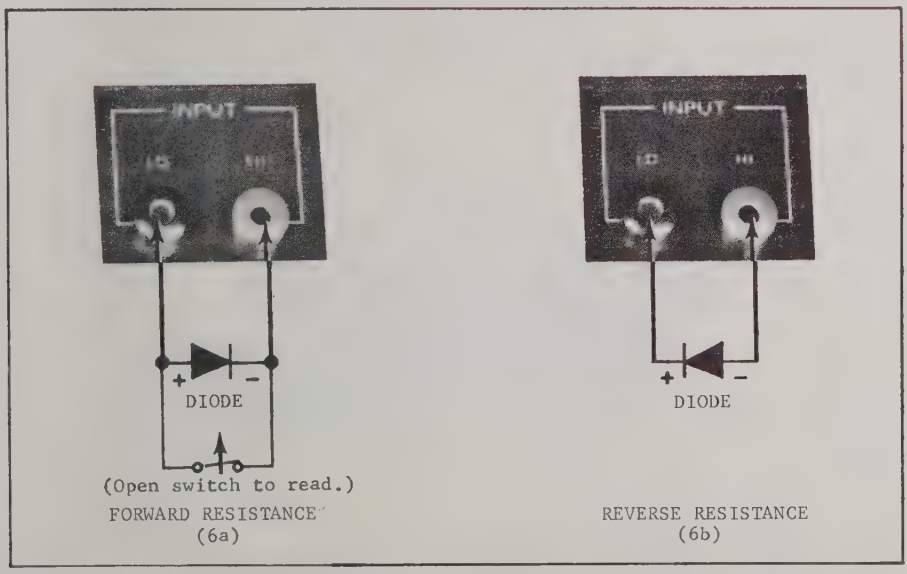


FIGURE 6. Measurement of Diode Resistance.

3-7. OPERATION AS AN AMMETER. When the Model 167 is used with the optional accessory Model 1673 Current Shunt, the Model 167 can be used to measure up to 2 amperes. To measure current set the Shunt Resistor to 1 ohm and connect the source in series with the 1673 terminals as shown in Figure 7. Install probe in front panel, select either "ACV" or "DCV" FUNCTION and observe reading on the display. Increase the Shunt Resistor until the maximum display is achieved not exceeding 2 volts. The current should then be calculated from the following formula: Current = Voltage / Shunt Resistance.

CAUTION

If the voltage across the shunt exceeds 2 volts the accuracy may be degraded and permanent damage may result.

NOTE

The accuracy for the Model 1673 Current Shunt is specified as $\pm$0.3%. The total inaccuracy when making a current measurement should include the basic accuracy of the Shunt Resistor, the Model 167, and the loading effects. The loading error in percent of reading can be calculated when the source resistance is known. The % error is equal to $100R/(Rs + R)$ where R = Shunt Resistance, Rs = Source Resistance.

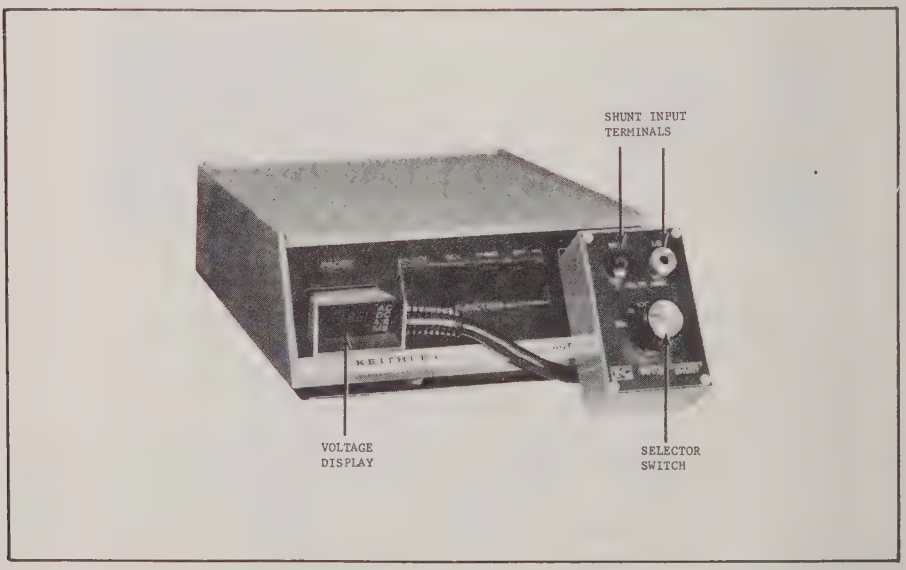
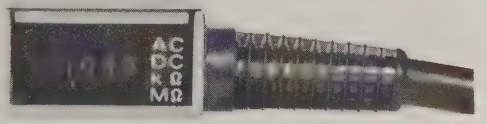


FIGURE 7. Operation As An Ammeter



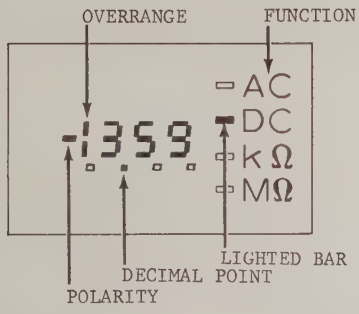


FIGURE 8. Digital Display

The digital display indicates three digits plus an overrange "1", decimal location, polarity, and function. A lighted bar identifies the function selected. When "DCV" is selected, the polarity for negative inputs is indicated by a "minus" sign. A positive polarity is not indicated, but a positive input is implied when the "minus" sign is turned off.

3-8. BATTERY OPERATION. The Model 167 is shipped from the factory with six alkaline "D" cells installed in the battery compartment so that the Model 167 is ready-to-use.

a. Battery Types Used in Model 167. The Model 167 operates from either of two types of batteries listed in Table 3-1. The alkaline cells are non-rechargeable and should be replaced when batteries are worn out. The nickel-cadmium cells are rechargeable when used with the optional Model 1671 Recharger.

b. Battery Test. To test the battery voltage while the Model 167 is operating, depress the "DCV" pushbutton and touch the probe to the "BATTERY TEST" terminal on the rear panel. Depress the "push-to-read" bar along the top of the probe and read the voltage displayed on the probe. Replace the alkaline cells if the voltage is less than 6 volts. If nickel-cadmium cells are installed, recharge using the Model 1671 Recharger if the voltage is less than 7 volts. The battery voltage should be at least 7 volts under load to ensure that the instrument will turn on.

NOTE

The 167 contains an automatic shut-down feature which turns off the instrument if the power input voltage is too low or a fault occurs inside the instrument.

c. Battery Replacement. The battery compartment is accessible from the underside of the Model 167 chassis. Remove the battery cover (Item 3) by unscrewing the three slotted screws (Item 5) as shown in Figure 9. Grasp the battery cover using the opening as a handle and gently lift the cover while pulling toward the front panel to release the tabs. Remove the worn out batteries. Replace with new batteries as recommended in Table 3-1. When installing batteries, observe the polarity marked in the battery compartment. Replace the battery cover by aligning the four tabs to mate with the four slots on the chassis toward the rear panel. Make certain the tabs are fully engaged so that the 3 screw holes align properly. Replace the 3 screws to complete the reassembly.

d. Battery Charging. To recharge the nickel-cadmium cells, connect the cable from the Model 1671 Recharger to the "AUXILIARY POWER" receptacle on the Model 167 rear panel. Set the "Line" switch on the Model 1671 to "117V" for voltages over the range of 90 to 125V rms or to "234V" for voltages over the range of 180 to 250V rms. Connect the line cord on the Model 1671 to a 50-60 Hz line voltage. The Model 1671 Recharger automatically charges the Model 167 whenever line voltage is connected. The charging rate is sufficient to completely recharge a set of nickel-cadmium cells within 16 hours. Since overcharging will not affect the batteries or the Recharger, the Model 167 can be recharged unattended without any problem. The Model 167 may be operated while the recharger is connected although the charging time will be longer.

CAUTION

Do not charge alkaline, zinc-carbon, or mercury batteries since the cells may leak or explode causing subsequent damage to the instrument.

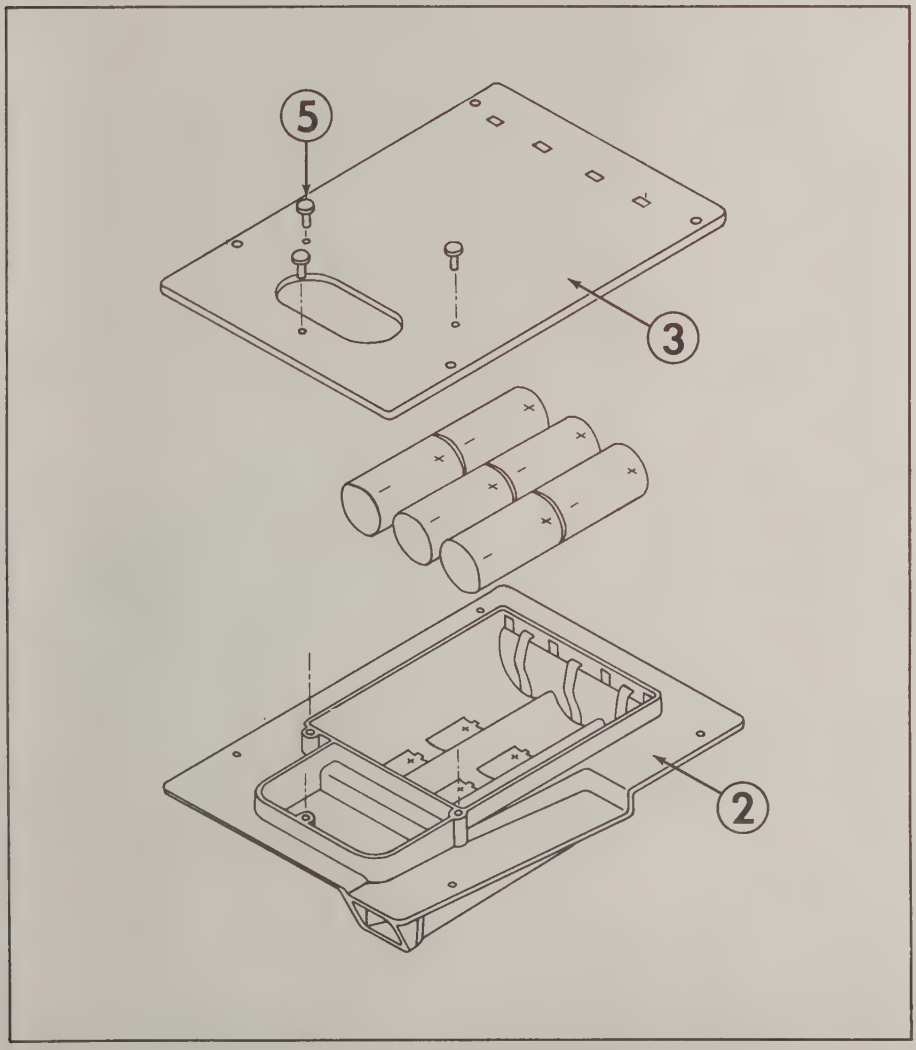


FIGURE 9. Battery Installation

3-9. LINE OPERATION. The Model 167 can be powered from line power when used with the optional Model 1672 Line Adapter. To operate from line power, connect the cable from the Model 1672 Line Adapter to the "AUXILIARY POWER" receptacle on the Model 167 rear panel. Set the "Line" switch on the Model 1672 to "117V" for voltages over the range of 90 to 125V rms or to "234V" for voltages over the range of 180 to 250V rms. Connect the line cord on the Model 1672 to a 50-60 Hz line voltage. The Model 1672 automatically powers the Model 167 whenever line voltage is connected. When batteries are installed the Model 1672 automatically switches to line operation as soon as the line cord is connected so that battery power is not used. If a line voltage failure occurs or the Model 1672 is disconnected, the Model 167 automatically switches to battery operation. If no batteries are installed, set the instrument to "OFF" before the line adapter is connected to ensure proper turn-on.

3-10. AUXILIARY POWER OPERATION. The Model 167 can be powered from an auxiliary power source supplying +7 to +15 volts dc at 2 watts. Connections should be made using the optional Model 1677 Power Cable which mates with the "AUXILIARY POWER" receptacle on the rear panel of the Model 167.

NOTE

The Model 167 has an automatic circuit that switches from battery operation to auxiliary power whenever an auxiliary voltage is applied which is greater than the battery test voltage. If the auxiliary voltage is removed or is less than the battery voltage, the Model 167 automatically switches to battery power. If no batteries are installed, set the instrument to "OFF" before the auxiliary power is applied to ensure proper turn-on.

3-11. BATTERY LIFE. The expected battery life is determined by usage per day, ambient temperature, and charge time (for Ni-Cad rechargeable batteries only).

a. Non-rechargeable Type (Alkaline). The useful battery life for this type will depend on the ambient temperature and the frequency of use. Alkaline batteries are recommended for up to 20 hours of continuous operation. When the "push-to-read" switch is used intermittently, the 167 operates for a much longer time. Since alkaline cells give maximum efficiency under intermittent drain, the actual useful life can be as great as 25,000 measurements (assuming about 3 seconds time per measurement). Battery life is reduced when operated at temperatures below 70°F although the instrument will operate down to 32°F.

b. Rechargeable Nickel-Cadmium Cells. The useful battery life for this type will depend on the temperature, frequency of use, and frequency and time of recharging prior to use. Ni-Cad cells are recommended for up to 12 hours continuous operation. Since the 167 utilizes a "push-to-read" bar, power is drawn from the batteries only when the bar is depressed to turn-on the instrument. Ni-Cad cells lose approximately 1% of potential per day when not used; therefore, recharging should be accomplished at least once per week to ensure adequate battery voltage. When using the Keithley accessory Model 1671, Ni-Cad cells should be recharged at least 16 hours to ensure a full charge. Overcharging will not harm the cells or the Recharger.

TABLE 3-1.
Recommended Battery Types

Description	Keithley Part No.	Manufacturer and Part No.
Alkaline "D" Cell	BA-26	Mallory MN1300
Nickel Cadmium "D" Cell	BA-27	Gould 4.0SCB

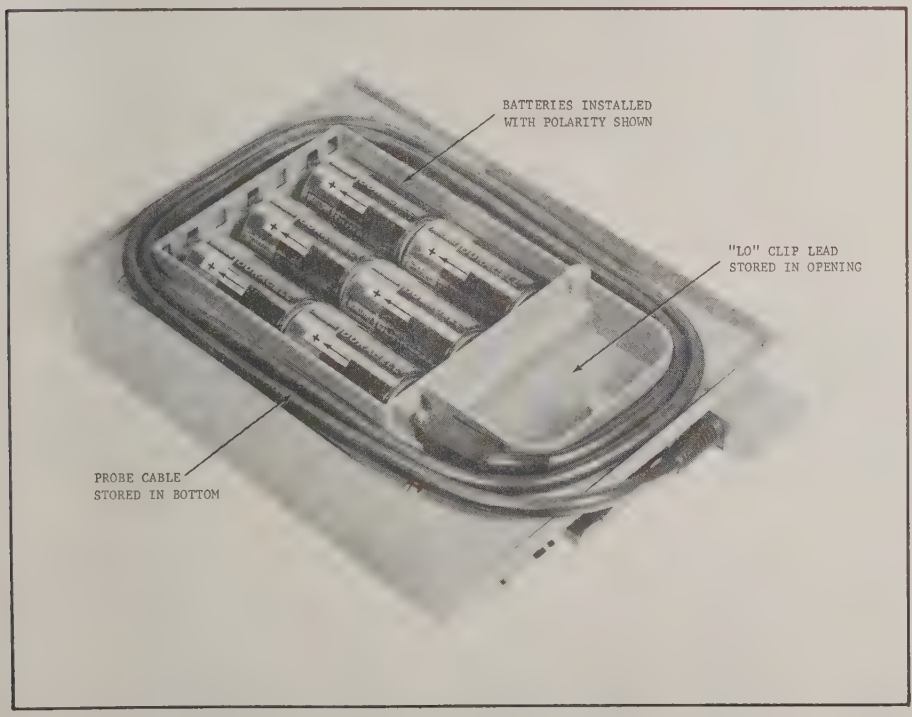


FIGURE 10. Battery Compartment

3-12. DISPLAY. The Model 167 display consists of a compact LED module installed in the probe. The display indicates 3 full digits plus overrange "1", automatic decimal location, automatic polarity, and range as shown in Figure 8. The individual digits are composed of seven-segments and are readable from a wide viewing angle since they are in one plane. A lighted bar identifies the function selected as either "ACV", "DCV", or "OHMS". When "DCV" is selected, the polarity is indicated as "-" for a negative input. A positive input is implied if the "-" sign is turned off. The lighted bar indicates either "kΩ" (kilohms) or "MΩ" (megohms) when the "OHMS" function is selected.

a. AC Volts. The 167 has four ranges for measurement of ac voltages. When "ACV" function is selected, the 167 automatically ranges to one of the ranges shown in Table 3-2. The 167 downranges whenever the input goes below 1-9-0. Upranging occurs whenever the input exceeds 1-9-9-9. When the input signal exceeds 499 volts rms, the display flashes on-and-off to indicate an overvoltage condition. The display continues to read up to the maximum allowable input.

TABLE 3-2.
AC Voltage Display (ACV)

Range	Min. Display	Max. Display
2V	.000 - AC	1.999 - AC
20V	1.90 - AC	19.99 - AC
200V	19.0 - AC	199.9 - AC
500V	190 - AC	499 - AC

b. DC Volts. The 167 has four ranges for measurement of dc voltages. When "DCV" function is selected, the 167 automatically ranges to one of the ranges shown in Table 3-3. The 167 downranges whenever the input goes below 1-9-0. Upranging occurs whenever the input exceeds 1-9-9-9. When the input signal exceeds ±999 volts, the display flashes to indicate an overvoltage condition. The display continues to read up to the maximum allowable input.

TABLE 3-3.
DC Voltage Display (DCV)

Range	Min. Display	Max. Display
2V	±.000 - DC	±1.999 - DC
20V	±1.90 - DC	±19.99 - DC
200V	±19.0 - DC	±199.9 - DC
1000V	±190 - DC	±999 - DC

c. OHMS. The 167 has five ranges for measurement of resistance. When "OHMS" function is selected, the 167 automatically ranges to one of the ranges shown in Table 3-4. The 167 downranges whenever the input goes below 1-9-0. Upranging occurs whenever the input exceeds 1-9-9-9. When the measured resistance exceeds 19.99 MΩ, the display flashes to indicate an overrange condition.

TABLE 3-4.
OHMS Display

Range	Min. Display	Max. Display	Test Current
2 kΩ	.000 - kΩ	1.999 - kΩ	900 μA
20 kΩ	1.90 - kΩ	19.99 - kΩ	90 μA
200 kΩ	19.0 - kΩ	199.9 - kΩ	9 μA
2 MΩ	.190 - MΩ	1.999 - MΩ	0.9 μA
20 MΩ	1.90 - MΩ	19.99 - MΩ	.09 μA

SECTION 4. THEORY OF OPERATION

4-1. GENERAL. This section contains information to describe the Model 167 circuit operation.

a. All circuitry is located on a single, glass-epoxy printed circuit board for ease of assembly and maintenance.

b. Compactness and high reliability are provided through the use of a digital LSI, a completely solid-state LED display, and thick-film resistor networks.

c. Low power dissipation is achieved through the use of an efficient switching regulator and all solid state construction.

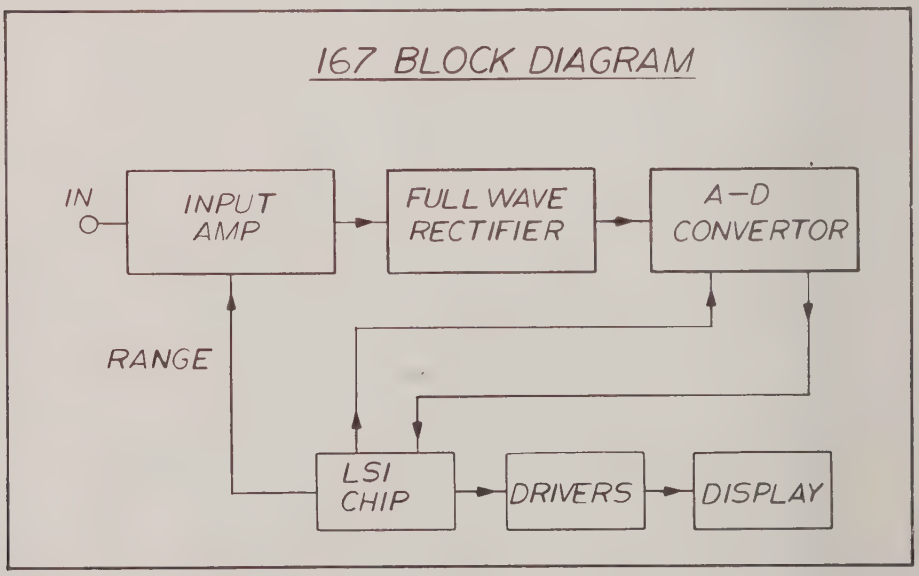


FIGURE 11. Overall Block Diagram

4-2. ANALOG CIRCUITRY.

a. Input Amplifier. The analog amplifier is a high gain, negative feedback amplifier. High input impedance is provided by the use of an FET input stage composed of Q103A and B. Potentiometer R104 is used to set input zero. Ranging is accomplished by switching the feedback resistors between the gate of Q103A and the output of integrated circuit QA101.

b. Full Wave Rectifier. This circuit develops a positive dc output for all inputs, ac or dc. An ac signal is full-wave rectified and filtered by the FWR. Integrated circuit QA102 is used for signal transfer for one polarity only. If the input to the rectifier is negative, QA103 provides a gain of -1 so that the output is positive. When the input to the rectifier is positive, QA103 provides a gain of -1 (the same as for negative inputs) except the output of QA102 is summed to provide a net gain of +1. QA102 provides an inverting gain of -2 which is summed at the "inverting input" of QA103. When the input to the rectifier is negative, the blocking action of diode D107 prevents the output of QA102 from going positive. Transistor Q108 conducts to maintain feedback around QA102 and also provides polarity information in the "DCV" function.

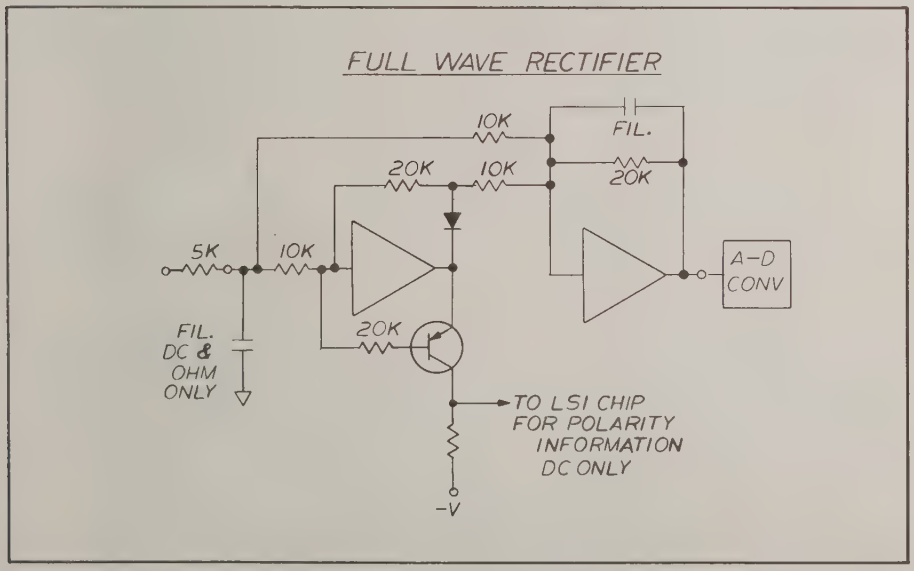


FIGURE 12. Full Wave Rectifier.

4-3. DIGITAL CIRCUITRY. All the digital circuitry is included in the LSI.

a. A-to-D Converter. The a-to-d converter operates on a charge balancing principle. The circuit operates only with unipolar inputs. A block diagram of the converter is shown in Figure 14. The positive output of the rectifier tends to drive the integrator output negative (amplifier QA104). The rate of integration is a function of the input, resistor RN103-2 and capacitor C120. As the integrator goes negative the threshold detector (amplifier QA105) output goes to a positive level. A positive level represents a "1" at the J input of the J-K flip-flop (the K input is a "0" due to the NAND gate). The charge and discharge periods for the integrator are determined by the state of the $\overline{Q}$ output on the J-K flip-flop. When the $\overline{Q}$ output is high, diode QA107-1 is back biased off and the integrator can only be charged by the FWR output. When the $\overline{Q}$ output is low, diode QA107-1 is forward biased and discharge of the integrator is possible. Since the Q and $\overline{Q}$ states can be changed only when a clock pulse is present, the charge/discharge periods are a function of the clock frequency as well. The a-to-d converter operates in a free running manner. The timing period is a total of 2016 counts. The reading is derived by counting the total number of clock pulses in the discharge period over a span of 2016 counts. This is accomplished by an AND gate as shown in Figure 20. For example, a 1 volt input would result in a total discharge period of 1000 counts. An input of 250 millivolts would represent 250 counts out of 2016. However, an input of 2.1 volts would cause the 167 to uprange since the total count would exceed 2000 which is the upranging level. The input filter ahead of the integrator provides up to 18 dB filtering at line frequencies. (The total normal mode filtering is approx. 55 dB at 60 Hz.)

NOTE

One complete conversion cycle is 2048 counts. The BCD counter looks at the threshold for 2016 counts. The remaining 32 counts are used to stop the BCD counter, strobe the BCD counter information into latches, reset the BCD counter to zero, and initiate uprange or downrange or overrange if necessary. 2048 counts at a 10 kHz rate is approx. 0.2 secs. per conversion (or 5 readings per second).

b. Autoranging Circuit. This circuitry is located on the LSI module QA201 with exception of decoding diodes D101 through D105, and FET switches Q104 through Q107 which are located on the main circuit board. The threshold input (TH) and current switch (CS) signals are used to determine the proper range. The range information is coded by three outputs identified as R_1, R_2, and R_4 as shown in Tables 4-2 and 4-3. Ranging is bidirectional so that on a given range the 167 will either uprange or downrange to the adjacent range. When on the lowest range the 167 is prohibited from downranging, and when on highest range it is prohibited from upranging.

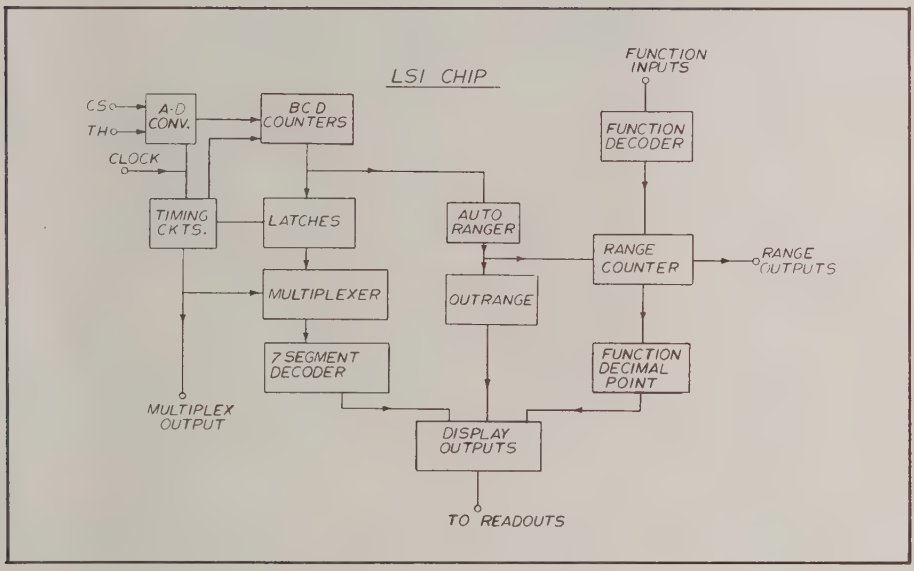


FIGURE 13. LSI Block Diagram

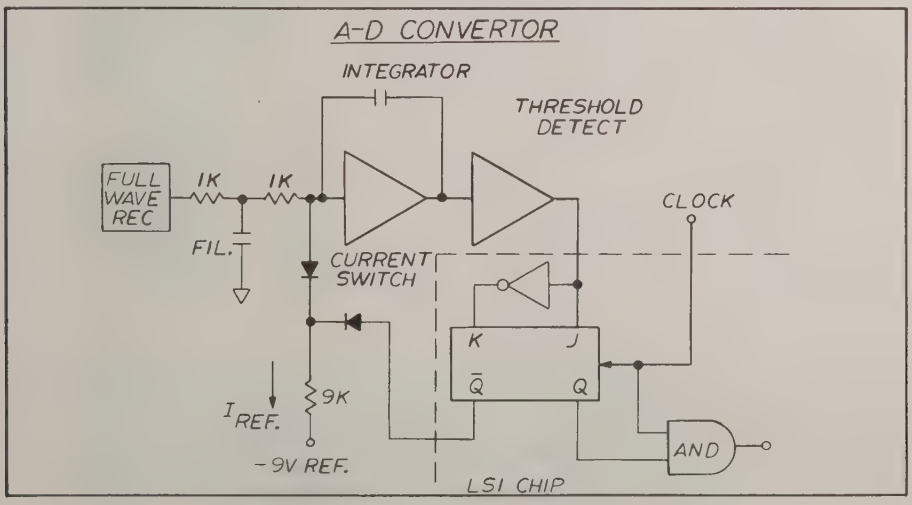


FIGURE 14. A/D Converter Block Diagram

TABLE 4-1.
Pin Identification for LSI

Pin No.	Designation	Function	Voltage Levels
1	R2	Range	+5V = logic "1", -12V = logic "0"
2	R1	Range	+5V = logic "1", -12V = logic "0"
3	F2	Function	+5V = logic "1", -12V = logic "0"
4	F1	Function	+5V = logic "1", -12V = logic "0"
5	-12V	Power, -12V	-12V
6	Iz	No connection	No connection
7	CLK	Clock	Approx. 10kHz, +5V to -12V
8	TH	Threshold input	+5V or -12V
9	CS	Current switch	+5V = integrate mode
10	T0	Multiplex line	+5V = ON, 0V = OFF
11	T1	Multiplex line	+5V = ON, 0V = OFF
12	T2	Multiplex line	+5V = ON, 0V = OFF
13	T3	Multiplex line	+5V = ON, 0V = OFF
14	a	Segment drive	+5V = ON, 0V = OFF
15	b	Segment drive	+5V = ON, 0V = OFF
16	c	Segment drive	+5V = ON, 0V = OFF
17	d	Segment drive	+5V = ON, 0V = OFF
18	e	Segment drive	+5V = ON, 0V = OFF
19	f	Segment drive	+5V = ON, 0V = OFF
20	g	Segment drive	+5V = ON, 0V = OFF
21	dp	Decimal point	+5V = ON, 0V = OFF
22	COM	Common or "LO"	0V
23	+5V	Power, +5V	+5V
24	R4	Range	+5V = logic "1", -12V = logic "0"

TABLE 4-2.
Ranging Logic for ACV and DCV

Range	R_1	R_2
2V	0	0
20V	1	0
200V	0	1
1000V	1	1

TABLE 4-3.
Ranging Logic for OHMS

Ohms	R_1	R_2	R_4
2 k	0	0	1
20 k	1	1	0
200 k	0	1	0
2 M	1	0	0
20 M	0	0	0

TABLE 4-4.
Function Logic

Function	Designation	
	F_1	F_2
ACV	1	0
DCV+	1	1
DCV-	0	1
OHMS	0	0

NOTE

With 3 range lines R_1, R_2, and R_4 there are 8 possible states of which four are used on ACV and DCV; five on OHMS. The remaining states may be established at instrument turn-on. The 167 logic is designed so that if these prohibited states occur at turn-on the logic circuitry will automatically shift into a defined state at end of first count cycle (0.2 seconds or less).

c. Digital Display. The display is a completely solid-state, 7-segment display which was custom-designed for the 167. The LED (light emitting diode) was chosen for its small size, ruggedness, and low power dissipation. Since each digit is turned on by a separate multiplex line, only eight lines are driven at any one time. Each segment is identified as shown in Figure 15.

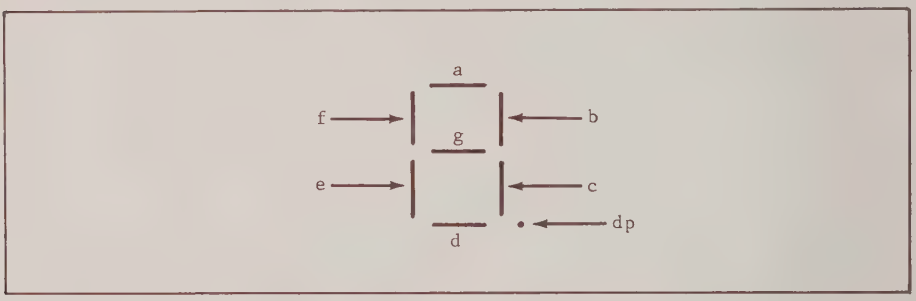


FIGURE 15. Identification of Segments.

d. Multiplexing Circuit. The multiplexing circuit is also included in integrated circuit QA201. The digital display is controlled by the four multiplexing lines which turn on the cathodes of each seven segment readout. Three of the lines are used for each of the three digits. The T_o line is used to indicate polarity, one, decimal point and the four FUNCTION bars. As a result, only 12 lines are required to operate the display. The multiplex lines are identified as To, T_1, T_2, and T_3 as shown in Figure 16.

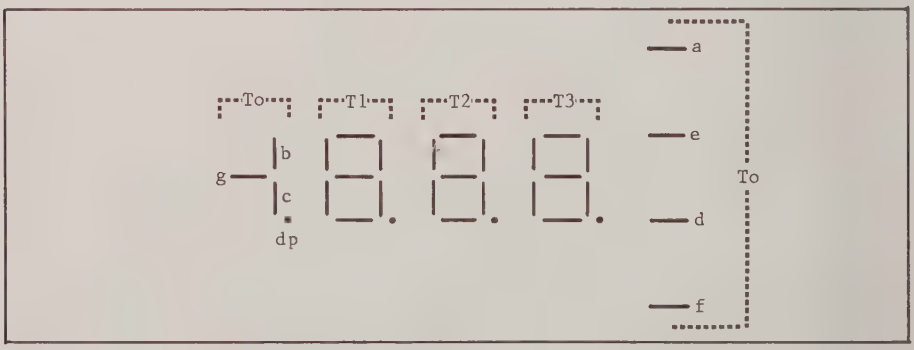


FIGURE 16. Identification of Multiplex Lines.

4-4. DC VOLTAGE OPERATION.

a. Gain. In the dc mode the input amplifier has a gain of 0.90 on the 2 volt range decreasing to 0.90 x 10^{-3} on the 1000 volt range. The gain for each range is determined by the feedback resistors as shown in Table 4-5.

TABLE 4-5.
Gain in DC Mode

Range	R_I	R_F	Gain
2V	55.5M	50M	0.90
20V	55.5M	5M	0.09
200V	55.5M	500K	0.009
1000V	55.5M	50K	0.0009

Since the input resistance is a constant value (55.5 MΩ), the source loading does not vary as the 167 changes range.

b. Calibration. Two internal adjust potentiometers R112 and R113 are used for calibrating the DCV function.

c. Filtering. In the dc mode, filtering is provided by capacitor C110 in the feedback loop. Additional filtering is accomplished by means of capacitors C114 and C115. The total filtering of the input amplifier is greater than 55 dB at line frequencies. Additional filtering is included in the FWR and a-d converter. If ac is superimposed on 1 Vdc input, typical NMRR is greater than 90 dB. The only time the low figure of 55 dB NMRR is achieved is when no dc is present at the input.

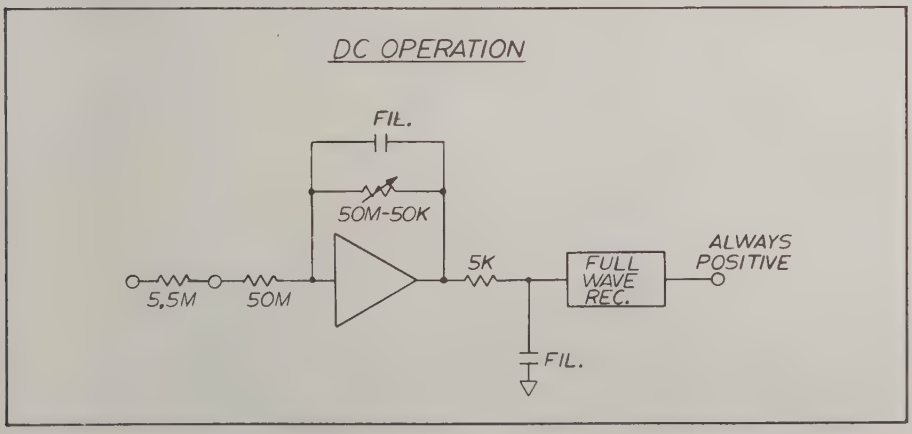


FIGURE 17. DC Voltage Operation.

4-5. AC VOLTAGE OPERATION.

a. Gain. In the ac mode the input amplifier has a gain of 1 on the 2 volt range decreasing to 0.001 on the 500 volt range. The gain for each range is determined by the feedback components as shown in Table 4-6.

TABLE 4-6.
Gain in AC Mode

Range	C_I*	R_I	R_F	C_F	Gain
2V	55 pF	50M	50M	55 pF	1
20V	55 pF	50M	5M	550 pF	0.1
200V	55 pF	50M	500K	0.0055 µF	0.01
500V	55 pF	50M	50K	0.055 µF	.001

*In addition to C_I the input cable from the probe adds approx. 165 pF capacity because there is a shielded coax cable inside the probe cable to carry the input signal. Thus, total input C as seen by the source is approximately 220 pF.

b. Frequency Response. The frequency response is from 20 Hz to 20 kHz. The ac ranges are calibrated through the use of three trimming capacitors C102, C105, and C107.

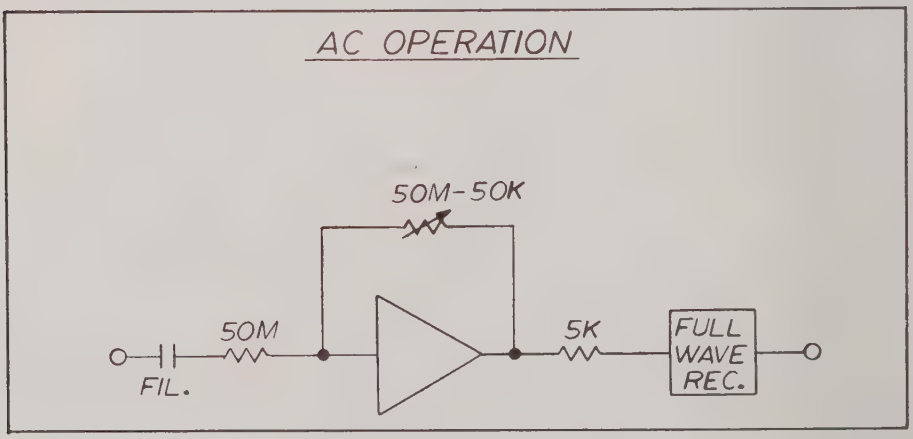


FIGURE 18. AC Voltage Operation

4-6. OHMS OPERATION. In the OHMS mode the input terminals ("HI" and "LO") are connected in the feedback path so as to reduce the slowing effects of cable capacitances. When the OHMS mode is selected a constant current is applied between the input terminals such that the LO terminal is positive. The current reference is composed of integrated circuit QA106 and range resistors RN101-3, -4, -5, and -6 which are used on voltage modes. An additional resistor R105 is used on the 10 MΩ range. The test current is determined by the -4.5V reference voltage and the range resistor. The voltage developed across the terminals is proportional to the measured resistance. For example, when a 15 megohm resistor is connected, the voltage developed is (4.5V ÷ 50M) x 15M = 1.35V. Potentiometer R115 is the adjustment for the 10 KΩ range. This control sets the output of QA106 to approximately -4.5 volts. Potentiometer R106 is the adjustment for the 1 KΩ range.

TABLE 4-7.
Test Current in OHMS Mode

Range	Test Current	Range Resistance	Voltage At Full Range
2 kΩ	900 µA	5 k	1.8V
20 kΩ	90 µA	50 k	1.8V
200 kΩ	9 µA	500 k	1.8V
2 MΩ	0.9 µA	5 M	1.8V
20 MΩ	0.09 µA	50 M	1.8V

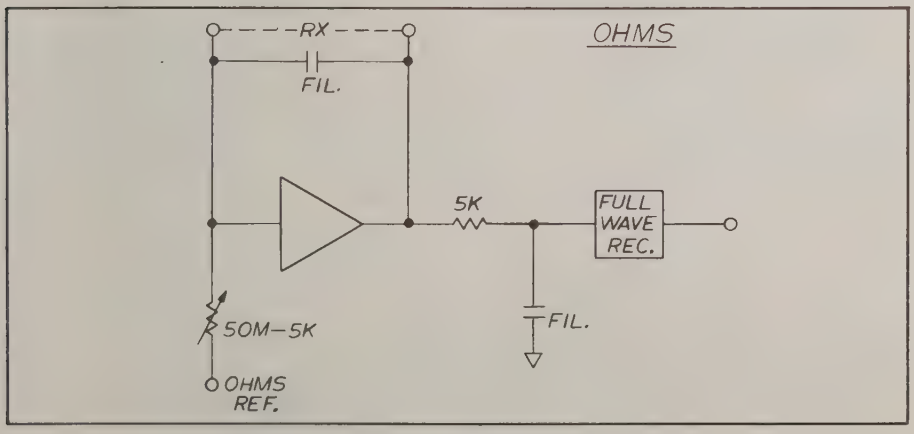


FIGURE 19. OHMS Operation

4-7. POWER SUPPLY.

a. Input Power.

1. Battery Pack. The 167 operates from 6 "D" cell batteries over a voltage range of +7V to +15V. The batteries are wired in series so as to provide a nominal 9 volts from six 1.5 volt cells. A blocking diode (D301) protects against wrong polarity when installing batteries. Thus, neither the batteries nor the instrument are harmed by a wrong polarity. The rear panel connector (P301) has a BATTERY TEST terminal which can be used to check the battery voltage at any time. The 167 probe can be used to self-check the battery voltage by merely touching the probe to terminal 2.

2. External Power. External power can be applied to the 167 through pin 3 of the rear panel connector. The 167 operates from any voltage over a range of +7V to +15V. Blocking diode D302 protects against inadvertent polarity reversal. Thus, neither the external source nor the instrument are harmed by a wrong polarity. Diodes D301 and D302 also perform a switching function when both internal batteries and external supply are connected. Whenever the external supply voltage is greater than the battery voltage, diode D301 is back biased off. If the external voltage is removed, diode D301 conducts and the instrument is powered by batteries (when installed in instrument).

b. Turn-on. The 167 power is controlled by the OFF pushbutton (S101) which shuts off the switching regulator. The PUSH-TO-READ switch (S301) is a normally-open type which is connected in series with the power switch S101. Thus, the 167 is powered only when S101 is closed and S301 is depressed. The turn-on time is less than 30 mS; therefore, the use of the PUSH-TO-READ switch extends useful battery life without sacrificing reading time.

c. Regulator Operation. The regulator is a switching-type which has high efficiency. Turn-on time is typically 30 mS. Transistors Q301 and Q302 alternately connect the battery supply to provide both +5V and -12V regulated power. Transistor Q303 controls the base current to the switching transistors in the event of a power failure. Integrated circuit QA301 is a regulating circuit which includes a reference amplifier (QA301B). The CLOCK waveform is provided at the collector of transistor Q305.

SECTION 5. MAINTENANCE

5-1. GENERAL. This section contains information necessary to maintain the instrument. Included are procedures for electrical Performance Checks, Calibration, Troubleshooting, Battery Replacement and Charging.

5-2. REQUIRED TEST EQUIPMENT. Recommended test equipment for checking and maintaining the instrument is given in Table 5-1. Test equipment other than recommended may be substituted if specifications equal or exceed the stated characteristics.

5-3. PERFORMANCE CHECKS. Use the following procedures to verify proper operation of the instrument. All measurements should be made at ambient temperature of approx. 25°C and relative humidity below 50%. If the instrument is out of specification at any point, perform a complete calibration as given in Paragraph 5-4.

NOTE

If it is necessary to recalibrate the instrument, the complete Calibration Procedure must be performed to ensure that all specifications are within tolerance.

TABLE 5-1.
Test Equipment

Item	Description	Specification	Mfr	Model
A	Digital Voltmeter	1 mV to 1000V ±0.1%	Keithley	160
B	Voltage Source	1V to 1000V ±0.05%	Keithley	241
C	Oscillator	20 Hz to 20 kHz	Hewlett Packard	202C
D	Resistance Source	1 kΩ to 10 mΩ ±0.03%	General Radio	1433
E	Ohmmeter (Electrometer)	100 to 10^{14}Ω ±3%	Keithley	610C
G	AC Calibrator	1 mV to 1000V ±0.02% 20 Hz to 20 kHz,	Hewlett Packard	745A/ 746A

a. Battery Check.

1. Check for proper installation of the batteries in the battery compartment.

2. Depress the "DCV" pushbutton and measure the "BATTERY TEST" terminal on rear panel using the probe.

3. If alkaline batteries are installed, the voltage should be greater than +6 volts. Replace the batteries if the voltage is too low.

4. If Ni-Cad batteries are installed, the voltage should be greater than +7 volts. Recharge the Ni-Cad batteries if the voltage is too low.

b. Accuracy Check.

1. DCV Function. Use Voltage Source (B) or equivalent test equipment.

a) Install the probe in the front panel.

b) Apply a dc voltage as given in Table 5-2 between "HI" and "LO".

c) Verify that the reading on the display is within the tolerance stated.

TABLE 5-2.
Accuracy Check for DCV

Source Input	Source Accuracy	Reading	Tolerance
1V	±0.02%	1.000	±3 digits
10V	±0.02%	10.00	±3 digits
100V	±0.02%	100.0	±3 digits
1000V	±0.02%	1000.	±3 digits

2. ACV Function. Use AC Calibrator (G) or equivalent test equipment.

a) Install the probe in the front panel.

b) Apply an ac voltage as given in Table 5-3.

c) Verify that the reading on the display is within the tolerances stated.

TABLE 5-3.
Accuracy Check for ACV

Source Input	Source Accuracy	Reading	Tolerance
1V @ 8 kHz	±0.1%	1.000	±12 digits
10V @ 8 kHz	±0.1%	10.00	±12 digits
100V @ 8 kHz	±0.1%	100.0	±12 digits
500V @ 1 kHz	±0.2%	500	±12 digits

3. OHMS Function. Use Resistance Source (D) or equivalent test equipment.

a) Install the probe in the front panel.

b) Apply a resistance as given in Table 5-4.

c) Verify that the reading on the display is within the tolerances stated.

TABLE 5-4.
Accuracy Check for OHMS

Source Input	Source Accuracy	Reading	Tolerance
1 kΩ	±0.03%	1.000 kΩ	±5 digits
10 kΩ	±0.03%	10.00 kΩ	±4 digits
100 kΩ	±0.03%	100.0 kΩ	±4 digits
1 MΩ	±0.03%	1.000 MΩ	±4 digits
10 MΩ	±0.03%	10.00 MΩ	±4 digits

c. Input Impedance.

1. Depress the "DCV" pushbutton.

2. Install the probe in the front panel.

3. Measure the input resistance using Ohmmeter E.

4. The resistance should be 55.5 MΩ ±5%.

d. Frequency Response.

1. Depress the "ACV" pushbutton.

2. Install the probe in the front panel.

3. Apply AC Calibrator (F) to input.

4. Set the amplitude for 1.000V reading at 20 Hz.

5. Maintain a fixed amplitude input and check readings for frequencies at 20, 50, 1 k, 5 k, 10 k, and 20 kHz (or any other convenient steps within 20 Hz to 20 kHz).

6. Readings should not vary more than ±12 digits from 20 Hz to 10 kHz. Readings should not vary more than ±24 digits from 20 Hz to 20 kHz.

e. AC Rejection.

1. Depress the "DCV" pushbutton.

2. Install the probe in the front panel.

3. Apply a 60 Hz sine wave using Oscillator (C).

4. Set oscillator output for 1V p-p.

NOTE

Reference oscillator should be transformer coupled so that no dc offset is introduced.

5. Connect a 1.5V battery in series with the oscillator signal.

6. The Model 167 should read approximately 1.5 volts.

7. When the 60 Hz signal is applied, the reading should not vary more than ±1 digit.

5-4. ADJUSTMENT AND CALIBRATION PROCEDURE. The following adjustments should be performed when any specification has been determined to be out-of-tolerance. The Performance Check given in paragraph 5-3 should be performed prior to this Calibration Procedure. If any step in the Calibration Procedure cannot be performed properly, refer to the Troubleshooting Procedure (paragraph 5-5) or contact your Keithley representative or the factory.

a. Chassis Disassembly. To gain access to the printed circuit board, remove the four slotted screws on the bottom panel as shown in Figure 20. Lift the top cover at the rear panel and open as shown in Figure 21. Before the calibration is performed, disconnect the leads attached to the input terminals on the front panel. Place the top cover on top of the printed circuit board such that the metal shield on the cover faces up. Make a temporary connection between "common" on the circuit board and the metal shield using a clip lead. The top cover now serves as an electrostatic shield when the calibration procedure is performed. Add jumper leads from the chassis to the front panel terminals so that the terminals are useable. When the calibration is completed, reconnect the front panel terminals and replace the top cover as shown in Figure 20.

NOTE

Follow the exact calibration sequence since the controls are interrelated.

b. Power Supply Check. Measure the dc voltages using Voltmeter A.

1. Measure the power supply voltage at integrated circuit QA101, pin 7. Use input "LO" as common. The voltage should be within the range from +4.75 to +5.25 volts.

2. Measure the power supply voltage at integrated circuit QA101, pin 4. Use input "LO" as common. The voltage should be within the range from -11.4 to -12.6 volts.

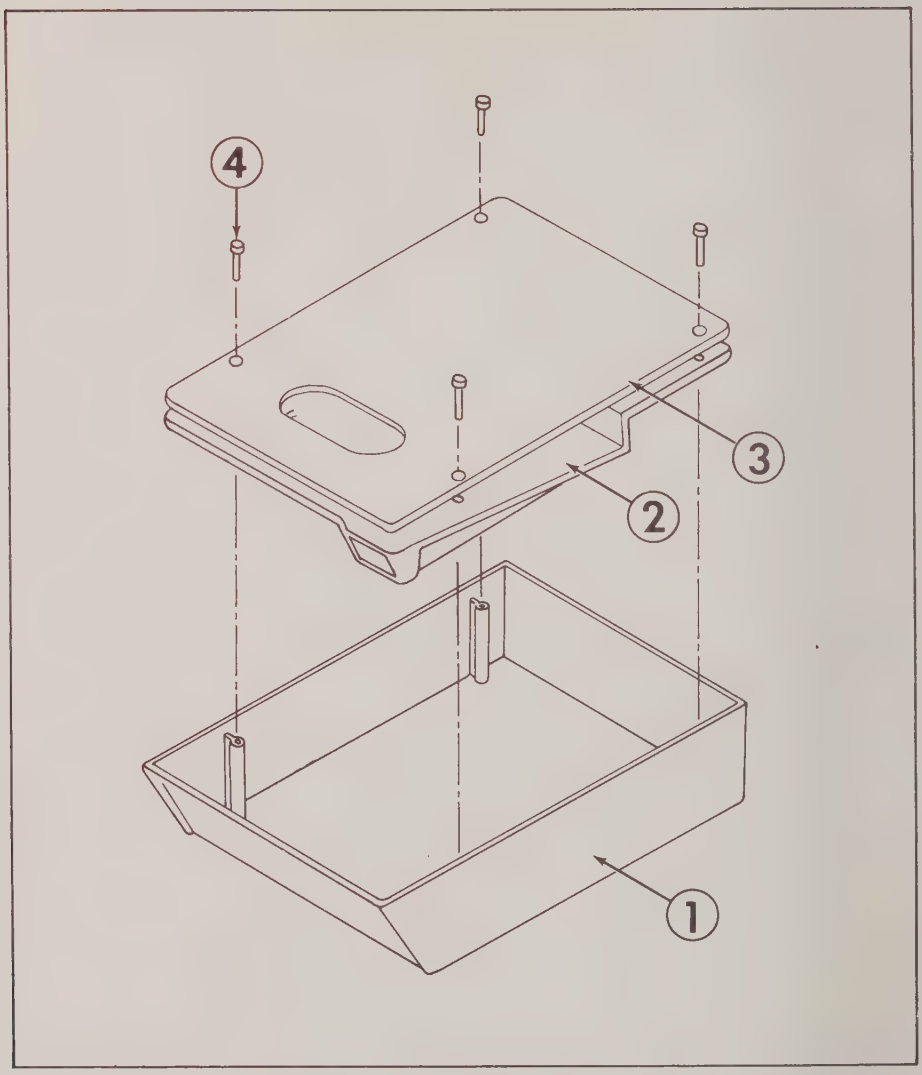


FIGURE 20. Top Cover Assembly

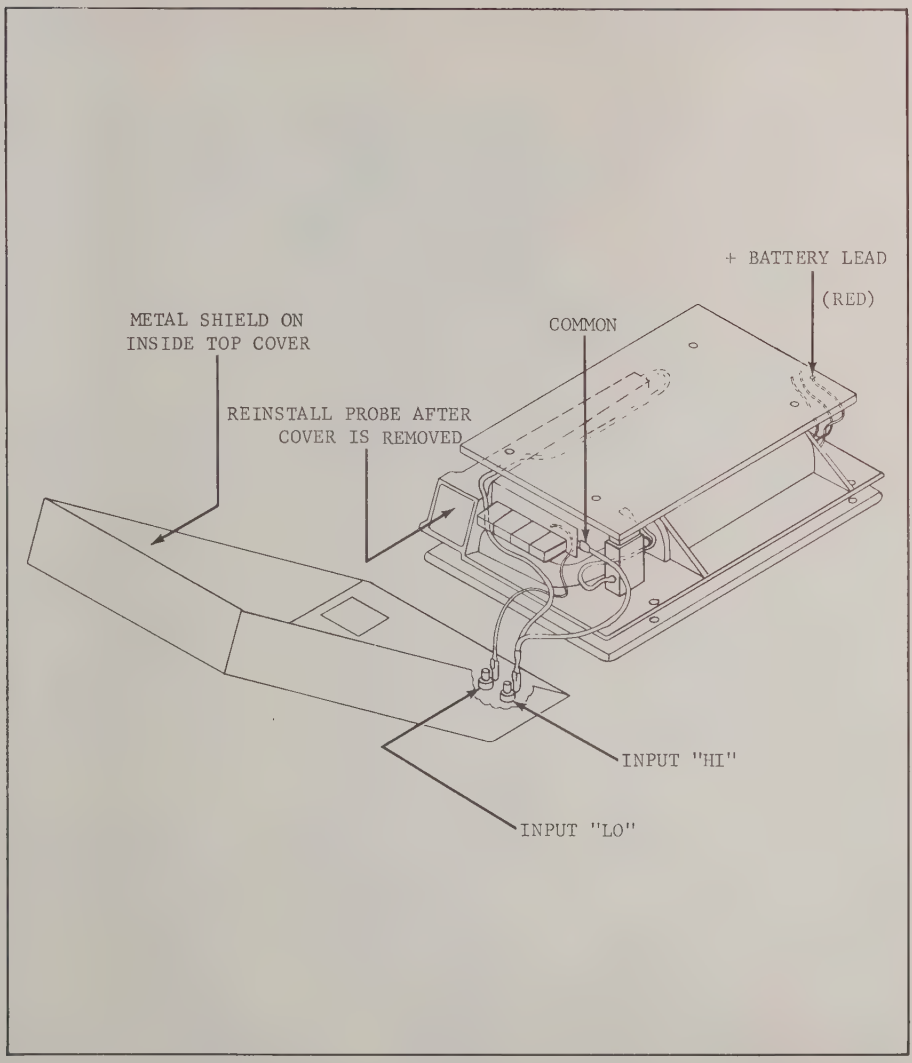


FIGURE 21. Chassis Assembly

c. DCV Calibration. (Use the "Calibration Shield" for all adjustments.)

1. Input Amplifier Zero.

a) Depress the "DCV" pushbutton.
b) Place a short circuit between "HI" and "LO".
c) Install the probe in the front panel. (The display should indicate approximately 0.000 Vdc.)
d) Connect Digital Voltmeter (A) between "TP1" and "LO".
✓ e) Adjust potentiometer R104 so that the voltage at "TP1" is 0.0000 ±100 µV.

2. Absolute Value/A-to-D Converter Zero. (Set the input amplifier zero before making the following adjustments.)

a) Depress the "DCV" pushbutton.
b) Apply +10 mV between "HI" and "LO".
c) Install the probe in the front panel.
✓ d) Adjust potentiometer R111 for +0.009 to +0.010 Vdc display reading.
e) Apply -10 mV between "HI" and "LO".
✓ f) Adjust potentiometer R110 for -0.009 to -0.010 Vdc display reading.
g) Repeat steps b) through f) to ensure that both adjustments are within tolerance.

3. DCV Accuracy Adjust.

a) Depress the "DCV" pushbutton.
b) Apply +1.000V ±0.02% between "HI" and "LO".
c) Install the probe in the front panel.
✓ d) Adjust potentiometer R112 for +1.000V display reading. (+DC CAL)
e) Apply -1.000V ±0.02% between "HI" and "LO".
✓ f) Adjust potentiometer R113 for -1.000V display reading. (-DC CAL)

TABLE 5-5.
Summary of Calibration Adjustments

Input	Source Accuracy	Display Reading	Control	Ref. Desig.
Shorted	-	±100 µV at TP1	INPUT ZERO	R104
+10 mV	±1%	+0.009 to +0.010V	DISPLAY ZERO	R111
-10 mV	±1%	-0.009 to -0.010V	RECT ZERO	R110
+1.000V	±0.02%	+1.000V	+DC CAL	R112
-1.000V	±0.02%	-1.000V	-DC CAL	R113
10 kΩ	±0.03%	10.00 kΩ	10 kΩ CAL	R115
1 kΩ	±0.03%	1.000 kΩ	1 kΩ CAL	R106
100V rms (8 kHz)	±0.1%	100.0V	100V AC CAL	C102
1V rms (8 kHz)	±0.1%	1.000V	1V AC CAL	C105
10V rms (8 kHz)	±0.1%	10.00V	10V AC CAL	C107

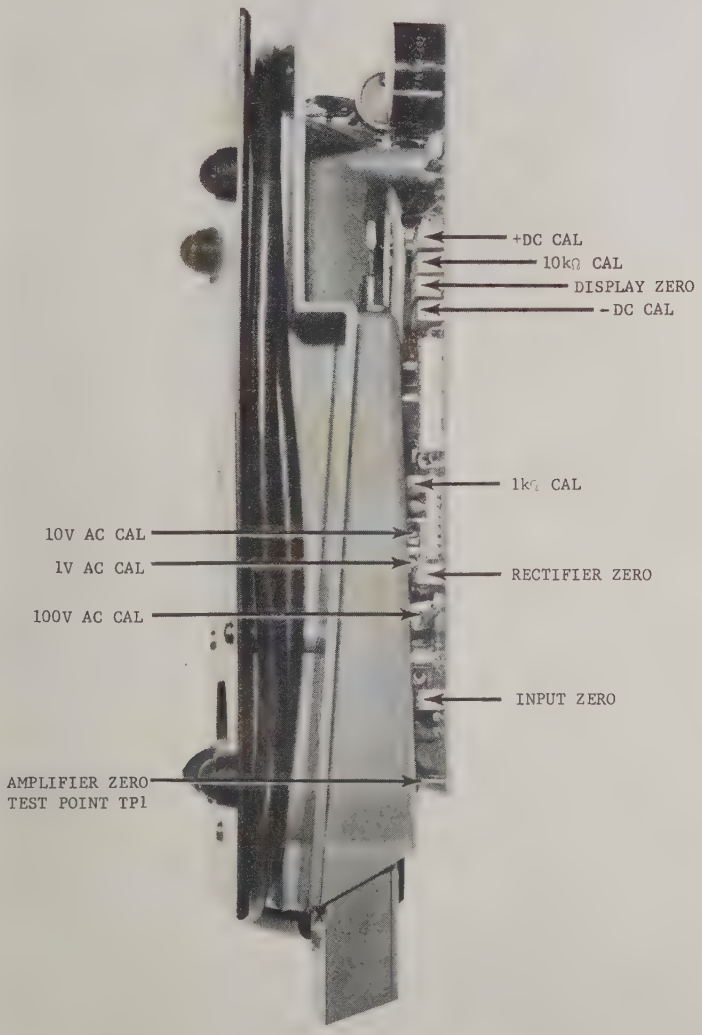


FIGURE 22. Calibration Controls

d. OHMS Calibration. (Perform the DCV Calibration before making the following adjustments.)

1. Reference Calibration.

a) Depress the "OHMS" pushbutton.
b) Apply a 10 kilohm resistance (±0.03%) between "HI" and "LO".
c) Install the probe in the front panel.
d) Adjust potentiometer R115 for 10.00 kΩ display reading. (10 kΩ CAL)

2. Range Adjust (1 kΩ).

a) Depress the "OHMS" pushbutton.
b) Apply a 1 kilohm resistance (±0.03%) between "HI" and "LO".
c) Install the probe in the front panel.
d) Adjust trimming capacitor C105 for 1.000 kΩ display reading. (1 kΩ CAL)

e. ACV Calibration. (Perform the DCV calibration before making the following adjustments.)

NOTE

Perform the adjustments in the exact sequence given so that proper calibration of accuracy results.

1. "100V" Range Adjustment. (This calibration also sets the 500V range.)

a) Depress the "ACV" pushbutton.
b) Apply a 8 kilohertz sinusoidal waveform using AC Calibrator (G). Set the amplitude for 100V rms.
c) Install the probe in the front panel.
d) Adjust trimming capacitor C102 for 100.0V display reading.

2. "1V" Range Adjustment.

a) Depress the "ACV" pushbutton.
b) Apply a 8 kilohertz signal using AC Calibrator (G). Set the amplitude for 1V rms.
c) Install the probe in the front panel.
d) Adjust trimming capacitor C105 for 1.000V display reading.

3. "10V" Range Adjustment.

a) Depress the "ACV" pushbutton.
b) Apply a 8 kilohertz signal using AC Calibrator (G). Set the amplitude for 10V rms.
c) Install the probe in the front panel.
d) Adjust trimming capacitor C107 for 10.00V display reading.

TABLE 5-6.
Troubleshooting Procedure

Difficulty	Probable Cause	Solution
(a) Display is blank	1) Batteries run down	Replace with alkaline "D" cells as explained in paragraph 5-7. (Recharge Ni-Cads if installed.)
	2) Malfunction of Push-to-Read switch	Remove top cover. Depress "OFF". Depress "push-to-read" bar on probe and measure resistance between pins 6 and 9 on connector J201. A low resistance reading indicates proper operation of switch.
	3) Malfunction of power supply.	Check red, blue, and black power leads for proper connection to circuit board. Refer to Figure 21 for proper locations. Check dc volts on integrated circuit QA101: Pin 7 should be +5V ±5%. Pin 4 should be -12V ±5%. (If voltages missing, see (c) below.)
	4) Malfunction of digital circuitry.	Check for supply voltages on each integrated circuit of the following: QA201 QA202 QA203 QA204
	5) Malfunction of display drivers.	Check for multiplex voltage on integrated circuit QA201 pins 10, 11, 12, or 13 using dc coupled oscilloscope. Waveform should measure between +4.5V and +0.5V. If voltages are measured, probable cause is QA204. If no voltages, probable cause is QA201 or QA204.
(b) Display is blank except for 1 digit.	1) Clock waveform is missing.	Check voltage at collector of transistor Q305 using dc coupled oscilloscope. Waveform should measure between +5V and -12V at approx. 10 kHz. If waveform is present, probable cause is QA201. If waveform is not present, probable cause is Q305.
	2) Integrated circuits QA201 or QA204.	Check multiplex signal as in (a5) above.

TABLE 5-6. (Cont'd)
Troubleshooting Procedure

Difficulty	Probable Cause	Solution
(c) No power supply voltages on QA101.	1) Switching transistors Q301, Q302.	Replace transistors Q301 and Q302.
	2) If display blinks and shuts down, probable cause is an output short circuit.	Check for faulty connection, shorted capacitor, diode, or transistor. Also check for loose solder, hardware, etc.
(d) Display flashes on-and-off on all FUNCTIONS.	Analog amplifier output is saturated.	Check analog section as follows: 1. Short input terminals. 2. Measure TP1 for zero. If output is high, check Q103 and QA101 for proper supply voltages. If supply voltages are normal, replace Q103 and QA101 and recheck zero. ✓ 3. If TP1 = 0, check TP2 for zero (within ±5 mv). If TP2 = 0, check QA102 and QA103. ✓ 4. If TP2 = 0, check QA104 and QA105.
(e) Minus signal does not operate for -DC input.	Integrated circuit QA107.	Replace QA107.
(f) One or more segments do not light when input is shorted.	Cable, driver circuits, or display module.	Check wiring to display. If problem persists, replace integrated circuit QA203. If an entire digit is blank, replace QA204. If just one segment of one digit malfunctions, then probable cause is display.
(g) Display indicates "kΩ" when ACV is depressed.	Integrated circuit QA107.	Replace QA107.
✓ (h) Display indicates 0-0-0 when input is open on "OHMS".	Improper wiring to front panel "LO". Failure of QA106.	Check for continuity between front panel "LO" and circuit low. If wiring is normal, check pin 6 of QA106 for -4.5 volts. If zero, replace QA106.
(i) 10 kΩ range is out of tolerance (other ranges are within spec.)	Resistor network RN101 out of tolerance. (Probably due to an overload on OHMS.)	Replace RN101.

5-5. TROUBLESHOOTING. If the instrument is out-of-tolerance for any specification, perform the Calibration Procedure given in Paragraph 5-4. If during the calibration an instrument malfunction is apparent, then proceed with the troubleshooting steps as given in Table 5-6.

5-6. BATTERY TEST. The 167 operates from battery voltages over the range of 7V to 15V. The instrument automatically turns off whenever the battery voltage is too low for proper operation. If the instrument shuts down or fails to turn on, simply replace the battery cells as explained in the following paragraph 5-7. When using Ni-Cad cells, recharge as explained in paragraph 5-8. To test the battery voltage (at any time when the Model 167 is operating), set the FUNCTION to "DCV" and use the probe to measure the "BATTERY TEST" terminal on the rear panel. Recharge Ni-Cad cells using the Recharger if voltage is below 7 volts. For all other battery types, replace the batteries if the voltage is less than 6 volts.

NOTE

To properly determine the battery potential, the cells must be measured in the 167 with power on, so that batteries are under load. Use the 167 probe to measure the "BATTERY TEST" terminal on the rear panel. To measure the battery potential with the cells outside the instrument, a 50Ω 2 watt resistor should be connected to simulate a load. The battery voltage should be at least 7 volts under load to ensure that the instrument will turn on.

5-7. BATTERY REPLACEMENT. The six "D" size battery cells used in the Model 167 are contained in the battery compartment as shown in Figure 10.

a. Replacement Batteries. The battery characteristics are given in Table 5-7. Worn out batteries should be replaced with the recommended types given in Table 5-8 to ensure optimum performance.

TABLE 5-7.
Battery Characteristics

Description	Volts Per Cell	Ampere Hour Rating	Maximum Dimensions
Alkaline, "D" size (Non-rechargeable) Type NEDA 13A	1.5V	10	1.31" dia. x 2.37" (33.3 mm x 60.2 mm)
Nickel-Cadmium, "D" size (Rechargeable)	1.25V	4	1.34" dia. x 2.41" (34.0 mm x 61.1 mm)

TABLE 5-8.
Replacement Batteries

Description	Keithley Part No.	Suggested Mfr and Part No.
Alkaline, Primary Cell	BA-26 (Order set of 6 as Model 1679)	Mallory MN1300
Nickel-Cadmium Cell	BA-27 (Order set of 6 as Model 1678)	Gould 4.OSCB

b. Battery Installation. The battery compartment is accessible from the underside of the Model 167 chassis. Remove the battery cover (Item 3) by unscrewing the three slotted screws (Item 5) as shown in Figure 9. Grasp the battery cover using the opening as a handle and gently lift cover while pulling toward the front panel to release tabs. Remove the worn out batteries. Replace with new batteries as recommended in Table 5-8. When installing batteries, observe the polarity marked in the battery compartment. Replace the battery cover by aligning the four tabs to mate with the four slots on the chassis toward the rear panel. Make certain the tabs are fully engaged so that the 3 screw holes align properly. Replace the 3 screws to complete the reassembly.

NOTE

The Model 167 is completely protected in the event of accidental polarity reversal. If the instrument fails to turn on after the replacement batteries have been installed, check each cell for correct polarity orientation. The batteries should supply at least 7 volts under load to ensure that the instrument will turn on.

5-8. BATTERY CHARGING. The Model 167 can be powered by rechargeable Ni-Cad batteries for up to 12 hours continuous operation. Ni-Cad cells should be recharged periodically so that they do not become fully discharged.

NOTE

If any one cell becomes discharged, the total voltage drops from approximately 7.5 volts to 6.25 volts. The instrument batteries should be recharged since reverse charging of the faulty cell may occur. If two cells discharge completely the voltage will drop below 6 volts and the instrument automatically shuts down.

a. Battery Charging. To recharge nickel-cadmium cells, connect the cable from the Model 1671 Recharger to the "AUXILIARY POWER" receptacle on the Model 167 rear panel. Set the "Line" switch on the Model 1671 to "117V" for voltages over the range of 90 to 125V rms or to "234V" for voltages over the range of 180 to 250V rms. Connect the line cord on the Model 1671 to a 50-60 Hz line voltage. The Model 1671 Recharger automatically charges the Model 167 whenever line voltage is connected. The charging rate is sufficient to completely recharge a set of nickel-cadmium cells within 16 hours. Since overcharging will not affect the batteries or the Recharger, the Model 167 can be recharged unattended without any problem.

CAUTION

Do not charge alkaline, zinc-carbon, or mercury batteries since the cells may leak or explode.

b. Battery Test. After recharging or replacing Ni-Cad cells, turn on the Model 167 to verify proper operation. If the instrument does not turn on, check the polarity orientation of each cell. If instrument turns on normally, check the battery voltage using the probe at the "BATTERY TEST" terminal on the rear panel. The voltage should be at least 7.2 volts for a fully charged set of Ni-Cad cells. If voltage is low, recharge at least eight more hours.* If in doubt, replace with a new set of Ni-Cad batteries. Order replacement batteries by specifying the Model 1678 Rechargeable batteries.

*NOTE

The Model 167 can be used for continuous operation with the Model 1671 connected, since the Recharger supplies power to the instrument automatically. The battery cells will be charged at a reduced rate, therefore, a longer recharging time will be required.

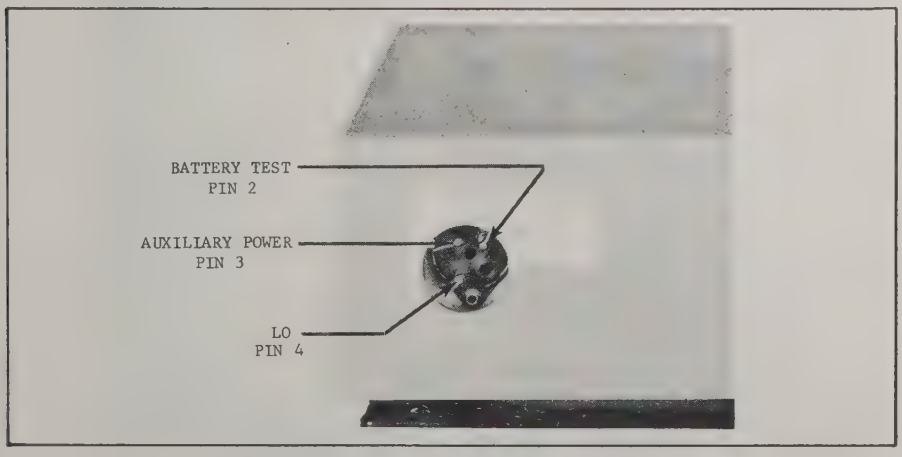


FIGURE 23. Auxiliary Power & Battery Check

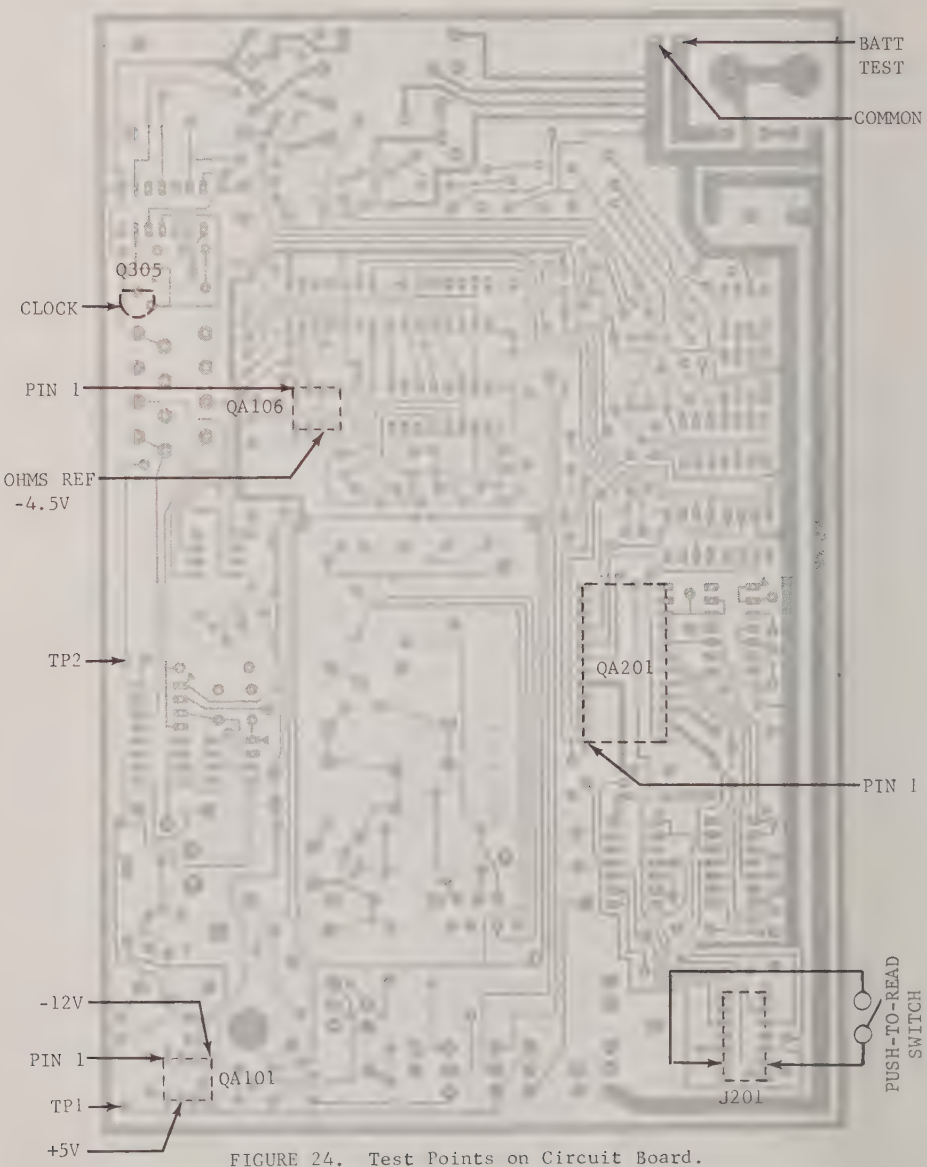


FIGURE 24. Test Points on Circuit Board.

SECTION 6. REPLACEABLE PARTS

6-1. GENERAL. This section contains information for ordering replacement parts. Table 6-2 lists the individual parts in alphameric order of their Circuit Designations giving location and corresponding Keithley stock part number. Table 6-3 lists the parts by the Circuit Designation number giving quantity per assembly, complete description, suggested manufacturer, manufacturer's designation, and Keithley part number used when ordering parts from the factory. Table 6-1 gives the abbreviations and symbols used in the instruction manual. A manufacturer code to name listing is given in Table 6-5.

6-2. ORDERING INFORMATION. To place an order or obtain information concerning replacement parts, contact your Keithley representative or the factory. When ordering parts, include the following information:

a. Instrument Model Number
b. Instrument Serial Number
c. Part Description
d. Circuit Designation (if applicable)
e. Keithley Stock Part Number

NOTE

Any part which is identified as a Keithley code 80164 is a custom designed or selected part available only from the factory.

TABLE 6-1.
Abbreviations, Symbols, and Designators

A, a	ampere
A	assembly
BT	battery
C	capacitor
CbVar	carbon variable
Cer D	ceramic disc
cer T	ceramic trimmer
Coef	coefficient
com	common
comp	composition
DCb	deposited carbon
Desig	designation
D	diode (all types)
DPDT	double-pole double-throw
DPST	double-pole single-throw
DS	lamp
elect	electrolytic
encap	encapsolated
EAL	electrolytic, aluminum
ETB	electrolytic, tubular
ETT	electrolytic, tantalum
F	farad (μF = 10^{-6} farad)
FET	field effect transistor
fempto	10^{-15}
FL	filter
fxd	fixed
Fig	figure
F	fuse
GaAs	gallium arsenide
GCb	glass enclosed carbon
Ge	germanium
grd	ground
H	henry (μH = 10^{-6} henry)
Hg	Mercury
Hz	hertz (cycles per second)
ID	inside diameter
in	inches (1 in = 25.4 mm)
J	jack
k	kilo (10^{3})
kΩ	kilohm (10^{3} ohms)
kHz	kilohertz (10^{3} Hz)
K	relay
L	inductor
lin	linear
log	logarithmic
LSI	large scale integrated circuit
M	meter or Meg (10^{6})
m	milli (10^{-3})
Meg	megohm ($10^{6}\Omega$)
mA	milliamperes (10^{-3}A)
mS	millisecond (10^{-3} seconds)
MΩ	megohm ($10^{6}\Omega$)
MtF	metal film
mfr	manufacturer
mtg	mounting
My	Mylar
nA	nanoampere (10^{-9}A)
no	number
NC	normally closed
NO	normally open
Ω	ohms
obd	order by description
OD	outside diameter
p	pico (10^{-12})
p	peak
pc	printed circuit
pF	picofarad (10^{-12} farad)
piv	peak inverse voltage
P	plug
poly	polystyrene
pot	potentiometer (variable resistor)
p-p	peak-to-peak
ppm	parts per million
Q	transistor
QA	integrated circuit (all types)
R	resistor
ref	reference
RN	resistor network
rms	root-mean-square
S	switch
SPDT	single-pole double-throw
SPST	single-pole single-throw
T	transformer
Tan	tantalum
TC	temperature coefficient
tol	tolerance
trim	trimmer
V	volt or vacuum tube (all types)
vac	volts; alternating current
vdc	volts, direct current
W	watt
ww	wirewound

6-3. CROSS REFERENCE. The circuit designations given in Table 6-2 refer to circuitry shown on the schematic diagrams. The location number for each part is shown on the component side of printed circuit PC-307. The Keithley part number is the stock number to be used when ordering replacement parts. The complete information for each part is given in Table 6-3.

TABLE 6-2.

Circuit Desig.	Loc.	Keithley Part No.	Circuit Desig.	Loc.	Keithley Part No.	Circuit Desig.	Loc.	Keithley Part No.
			ANALOG CIRCUITRY Schematic 25342D					
C101	49	C224-.01M	D101	67	RF-28	R101	45	R76-1M
C102	56	C225-.8-18P	D102	68	RF-28	R102	40	R88-49.9K
C103	50	C226-39P	D103	66	RF-28	R103	39	R88-49.9K
C104	54	C226-33P	D104	69	RF-28	R104	41	RP89-20K
C105	57	C225-.8-18P	D105	65	RF-28	R105	59	R34-4.5K
C106	60	C209-485P	D106	75	DZ-41	R106	63	RP89-1K
C107	58	C225-.8-18P	D107	32	RF-28	R107	29	R76-1K
C108	52	C222-.0055M	D108	70	RF-28	R108	30	R76-120K
C109	53	C222-.0495M	Q101	64	TG-43 *	R109	51	R76-12K
C110	62	C221-.001M	Q102	55	TG-43 *	R110	35	RP89-500
C111	61	C221-.0033M	Q103	38	TG-89	R111	26	RP89-10K
C112	37	C22-470P	Q104	74	TG-88	R113	27	RP89-1K
C113	42	C64-5P	Q105	73	TG-88	R112	24	RP89-1K
C114	46	C228-39M	Q106	72	TG-88	R114	36	R76-820
C115	47	C228-39M	Q107	71	TG-88	R115	25	RP89-2K
C116	33	C64-5P	Q108	31	TG-61	R116	-	R76-47
C117	34	C64-150P	QA101	19	IC-24	R117	-	R76-270K
C118	28	C221-1M	QA102	18	IC-24	RN101	133	TF-6
C119	76	C228-39M	QA103	12	IC-42	RN102	2	TF-2
C120	107	C1[illegible]-.1M	QA104	15	IC-42	RN103	3	TF-3
C121	114	C22-.001M	QA105	16	IC-42	RN104	5	TF-5
			QA106	13	IC-42	S101	132	SW-352
			QA107	4	IC-53			
			*Selected part, 25505A.					
			DIGITAL CIRCUITRY Schematic 25343D					
C201	109	C22-.001M	C207	118	C22-.001M	C213	117	C22-.001M
C202	108	C22-.001M	C208	112	C22-.001M	C214	113	C22-.001M
C203	110	C22-.001M	C209	122	C22-.01M	J201	10	SO-66
C204	111	C22-.001M	C210	121	C22-.01M	QA201	11	LSI-1
C205	120	C22-.001M	C211	115	C22-.001M	QA202	8	IC-38
C206	119	C22-.001M	C212	116	C22-.001M	QA203	7	IC-38
						QA204	9	IC-52
			POWER SYSTEM Schematic 25340D					
C301	91	C179-10M	D301	96	RF-42	QA302	14	IC-42
C302	90	C179-10M	D302	97	RF-42	Q301	80	TG-90
C303	21	C179-2.2M	D303	22	RF-28	Q302	81	TG-90
C304	89	C179-1.2M	D304	100	RF-28	Q303	79	TG-49
C305	83	C179-2.2M	D305	101	RF-28	Q304	105	TG-49
C306	126	C229-1000M	D306	102	RF-28	Q305	23	TG-53
C307	84	C64-47P	D307	77	RF-28	R301	88	R201-.1
C308	20	C64-5P	D308	82	RF-41	R302	87	R201-.1
C309	123	C22-.01M	D309	78	RF-41	R303	85	R201-.39
C310	95	C179-10M	L301	103	CH-14	R304	86	R201-.16
C311	94	C179-10M	L302	104	CH-14	R305	99	R88-10
C312	106	C64-150P	P302	129	24249A	R306	98	R76-180
C313	125	C160-1000M	P303	128	24249A	RN301	1	TF-4
C314	92	C179-10M	P304	127	24249A	RN302	17	TF-1
C315	93	C179-10M	QA301	6	IC-25	T301	124	TR-144

6-4. PARTS LIST. The complete information for each component is given in Table 6-3. Each part is listed by the circuit designations, followed by the description, manufacturer, manufacturer's designation, Keithley Part Number, and total quantity per assembly. In general the description of each part is given in the following order. Value, tolerance, rating, and type.

TABLE 6-3.
Replaceable Parts List

Circuit Desig.	Description	Mfr.	Mfr. Desig.	Keithley Part No.	Qty.
		CAPACITORS			
C101	.01μF, 20%, 600V, MPC	14752	625B1F103-20%	C224-.01M	1
C102	.8-18pF, 750V, Var, Glass	72982	567-013	C225-.8-18P	3
C103	39pF, 5%, 500V, Cer	72982	0302043C0G0390J	C226-39P	1
C104	33pF, 5%, 500V, Cer	72982	0302043C0G0330J	C226-33P	1
C105	.8-18pF, 750V, Var, Glass	72982	567-013	C225-.8-18P	-
C106	485pF, 1%, 500V, Silver Mica	14655	CD15FD485F03	C209-485P	1
C107	.8-18pF, 750V, Var, Glass	72982	567-013	C225-.8-18P	-
C108	.0055μF, 1%, 200V, MPC	14752	625B1C552F-1%	C222-.0055M	1
C109	.0495μF, 1%, 200V, MPC	14752	625B1C4952F-1%	C222-.0495M	1
C110	.001μF, 20%, 200V, My	14752	625B1C102-20%	C221-.001M	1
C111	.0033μF, 20%, 200V, My	14752	625B1C332-20%	C221-.0033M	1
C112	470pF, 10%, 600V, CerD	72982	831000X5F0-471K	C22-470P	1
C113	5pF, 10%, 1000V, CerD	71590	DD050-10%	C64-5P	3
C114	39μF, 10%, 15V Epoxy	17554	TD4-015-396-10	C228-39M	3
C115	39μF, 10%, 15V Epoxy	17554	TD4-015-396-10	C228-39M	-
C116	5pF, 10%, 1000V, CerD	71590	DD050-10%	C64-5P	-
C117	150pF, 10%, 1000V, CerD	71590	DD151-10%	C64-150P	2
C118	1μF, 20%, 200V, My	14752	625B1C105-20%	C221-1M	1
C119	39μF, 10%, 15V Epoxy	17554	TD4-015-396-10	C228-39M	-
C120	.1μF, 20%, 200V, MPC	97419	M2WR-104-20%	C143-.1M	1
C121	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	13
C201	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C202	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C203	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C204	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	
C205	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C206	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C207	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C208	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C209	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C210	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C211	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C212	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C213	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-
C214	.001μF, 10%, 600V, CerD	72982	801000X5F0-102K	C22-.001M	-

Circuit Desig.	Description	Mfr.	Mfr. Desig.	Keithley Part No.	Qty.
	CAPACITORS (cont'd)				
C301	10μF, 20%, 20V, Tant	17554	TD2-20-106-20	C179-10M	6
C302	10μF, 20%, 20V, Tant	17554	TD2-20-106-20	C179-10M	-
C303	2.2μF, 20%, 20V, Tant	17554	TD1-20-225-20	C179-2.2M	2
C304	1.2μF, 20%, 20V, Tant	17554	TD1-20-125-20	C179-1.2M	1
C305	2.2μF, 20%, 20V, Tant	17554	TD1-20-225-20	C179-2.2M	-
C306	1000μF, 10%, 6.4V, EAL	73445	C437AR/C1000	C229-1000M	1
C307	47pF, 10%, 1000V, CerD	71590	DD470-10%	C64-47P	1
C308	5pF, 10%, 1000V, CerD	71590	DD050-10%	C64-5P	-
C309	.01μF, 10%, 600V, CerD	56289	5GAS-S10-103	C22-.01M	3
C310	10μF, 20%, 20V, Tant	17554	TD2-20-106-20	C179-10M	-
C311	10μF, 20%, 20V, Tant	17554	TD2-20-106-20	C179-10M	-
C312	150pF, 10%, 1000V, CerD	71590	DD151-10%	C64-150P	2
C313	1000μF, 25V, EMC	73445	ET102X025A03	C160-1000M	1
C314	10μF, 20%, 20V, Tant	17554	TD2-20-106-20	C179-10M	-
C315	10μF, 20%, 20V, Tant	17554	TD2-20-106-20	C179-10M	-
	DIODES				
D101	Silicon	01295	1N914	RF-28	12
D102	Silicon	01295	1N914	RF-28	-
D103	Silicon	01295	1N914	RF-28	-
D104	Silicon	01295	1N914	RF-28	-
D105	Silicon	01295	1N914	RF-28	-
D106	Zener	06751	1N937	DZ-41	2
D107	Silicon	01295	1N914	RF-28	-
D108	Silicon	01295	1N914	RF-28	-
D301	Rectifier	04713	MR751	RF-42	2
D302	Rectifier	04713	MR751	RF-42	-
D303	Silicon	01295	1N914	RF-28	-
D304	Silicon	01295	1N914	RF-28	-
D305	Silicon	01295	1N914	RF-28	-
D306	Silicon	01295	1N914	RF-28	-
D307	Silicon	01295	1N914	RF-28	-
D308	Rectifier	07263	1N4607	RF-41	2
D309	Rectifier	07263	1N4607	RF-41	-

Circuit Desig.	Description	Mfr.	Mfr. Desig.	Keithley Part No.	Qty.
	INTEGRATED CIRCUITS				
QA101	Operational Amplifier,8-Pin DIP	12040	LM301AN	IC-24	2
QA102	Operational Amplifier,8-Pin DIP	12040	LM301AN	IC-24	-
QA103	Operational Amplifier,8-Pin DIP	07263	U9T7741393	IC-42	5
QA104	Operational Amplifier,8-Pin DIP	07263	U9T7741393	IC-42	-
QA105	Operational Amplifier,8-Pin DIP	07263	U9T7741393	IC-42	-
QA106	Operational Amplifier,8-Pin DIP	07263	U9T7741393	IC-42	-
✓ QA107	Operational Amplifier,8-Pin DIP	07263	U9T7741393	IC-42	-
QA201	Integrated Circuit 24-Pin DIP	80164	LSI-1	LSI-1	1
QA202	NAND Gates, 14-Pin DIP	18324	N7400A	IC-38	2
QA203	NAND Gates, 14-Pin DIP	18324	N7400A	IC-38	-
QA204	NAND Gates, 14-Pin DIP	04713	MC858P	IC-52	1
QA301	Voltage Regulator, 14-Pin DIP	07263	U6A7723393	IC-25	1
QA302	Operational Amplifier,8-Pin DIP	07263	U9T7741393	IC-42	-
	RESISTORS				
R101	1MΩ, 10%, 1/4 W, Comp (RC07)	44655	CB-105-10%	R76-1M	1
R102	49.9KΩ, 1%, 1/8 W, MtF	91637	MFF-1/8-T1-493	R88-49.9K	2
R103	49.9KΩ, 1%, 1/8 W, MtF	91637	MFF-1/8-T1-493	R88-49.9K	-
R104	20KΩ, 10%, .75 W, Comp Var	73138	89PR20K	RP89-20K	1
R105	4.5KΩ, 1%, 10 W, WW	91637	RS-10-453-1%	R34-4.5K	1
R106	1KΩ, 10%, .75 W, Comp Var	73138	89PR1K	RP89-1K	3
R107	1KΩ, 10%, 1/4 W, Comp (RC07)	44655	CB-103-10%	R76-1K	1
R108	120KΩ, 10%, 1/4 W, Comp (RC07)	44655	CB-124-10%	R76-120K	1
R109	12KΩ, 10%, 1/4 W, Comp (RC07)	44655	CB-123-10%	R76-12K	1
R110	500Ω, 10%, .75 W, Comp Var	73138	89PR500	RP89-500	1
R111	10KΩ, 10%, .75 W, Comp Var	73138	89PR10K	RP89-10K	1
R112	1KΩ, 10%, .75 W, Comp Var	73138	89PR1K	RP89-1K	-
R113	1KΩ, 10%, .75 W, Comp Var	73138	89PR1K	RP89-1K	-
R114	820Ω, 10%, 1/4 W, Comp (RC07)	44655	CB-821-10%	R76-820	1
R115	2KΩ, 10%, .75 W, Comp Var	73138	89PR2K	RP89-2K	1
R116	47Ω, 10%, 1/4 W, Comp	44655	CB-470-10%	R76-47	1
R117	270KΩ, 10%, 1/4 W, Comp	44655	CB-274-10%	R76-270K	1
R301	.1Ω, 5%, 2 W, WW	75042	BWH-2W-0.1-5%	R201-.1	2
R302	.1Ω, 5%, 2 W, WW	75042	BWH-2W-0.1-5%	R201-.1	2
R303	.39Ω, 5%, 2 W, WW	75042	BWH-2W-0.39-5%	R201-.39	1
R304	.16Ω, 5%, 2 W, WW	75042	BWH-2W-0.16-5%	R201-.16	1
R305	10Ω, 1%, 1/8 W, MtF	91637	MFF-1/8-T1-100	R88-10	1
R306	180Ω, 10%, 1/4 W, Comp (RC07)	44655	CB-181-10%	R76-180	1

Circuit Desig.	Description	Mfr.	Mfr. Desig.	Keithley Part No.	Qty.
	THICK FILM NETWORKS				
RN101	Resistor Network	80164	TF-6	TF-6	1
RN102	Resistor Network	80164	TF-2	TF-2	1
RN103	Resistor Network	80164	TF-3	TF-3	1
RN301	Resistor Network	80164	TF-4	TF-4	1
RN302	Resistor Network	80164	TF-1	TF-1	1
✓	Sheet 3 of 3				
	TRANSISTORS				
Q101	NPN Silicon, TO-5 Case(selected)	02734	40317	TG-43 (25505A)	2
Q102	NPN Silicon, TO-5 Case(selected)	02734	40317	TG-43 (25505A)	-
Q103	Dual N-Channel FET TO-71 Case	32293	ITS3736	TG-89	1
Q104	N-Channel FET TO-18 Case	32293	ITS3538	TG-88	4
Q105	N-Channel FET TO-18 Case	32293	ITS3538	TG-88	-
Q106	N-Channel FET TO-18 Case	32293	ITS3538	TG-88	-
Q107	N-Channel FET TO-18 Case	32293	ITS3538	TG-88	-
Q108	PNP, Silicon, TO-92 Case	07263	2N5087	TG-61	1
✓ Q301	NPN, TO-106 Case	12040	2N4355	TG-90	2
✓ Q302	NPN, TO-106 Case	12040	2N4355	TG-90	-
Q303	NPN, Silicon, TO-92 Case	07263	2N3903	TG-49	2
Q304	NPN, Silicon, TO-92 Case	07263	2N3903	TG-49	-
Q305	PNP, Silicon, TO-92 Case	07263	2N3905	TG-53	1
	MISCELLANEOUS				
B1	Battery, D-Cell, Alkaline	90303	MN1300MOD1	BA-26	6
B2	Battery, D-Cell, Alkaline	90303	MN1300MOD1	BA-26	-
B3	Battery, D-Cell, Alkaline	90303	MN1300MOD1	BA-26	-
B4	Battery, D-Cell, Alkaline	90303	MN1300MOD1	BA-26	-
B5	Battery, D-Cell, Alkaline	90303	MN1300MOD1	BA-26	-
B6	Battery, D-Cell, Alkaline	90303	MN1300MOD1	BA-26	-
J102	Banana Jack, Black	83330	205B	BJ-7B	1
J103	Banana Jack, Red	83330	205R	BJ-7R	1
J201	Socket, dual-in-line, 14-pins	71785	14-DIP	SO-66	1
L301	Choke, 100μH	72259	SWD-100	CH-14	2
L302	Choke, 100μH	72259	SWD-100	CH-14	-
✓ T301	Transformer	80164	TR-44	TR-44	1
---	Digital Display	80164	DD-1	DD-1	1

TABLE 6-4. ✓ SEE CHANGE NOTICE
Chassis and Probe Assemblies

Assembly	Description	Item	Qty	Keithley Part No.
Top cover	Cover, plastic	(1)	1	24621D
	Overlay, front panel		1	25173B
	Banana jack, black		1	BJ-7B
	Banana jack, red		1	BJ-7R
	Shield plate		1	25184B
	Shield insulator		1	25500B
	Metalcal, rear panel		1	MC-178
	Lug (banana jack)		2	LU-46
	Screw, #6-32 x 5/16, slotted	(4)	4	obd
Battery box	Base plate	(3)	1	24622D
	Foot, rubber ball		4	FE-6
	Foam cushion		3	25191A
	Battery compartment	(2)	1	24620D
	Clips		6	24536B
	Probe connector		1	TJ-11
	Guide, probe tip		1	24624A
	Screw, #6-32, slotted	(5)	3	25368A
Circuit board	Board, with components		1	PC-307
	Screw, #6-32 x 5/16, Phil Hd		4	obd
	Stand-off		2	ST-111
	Cable with socket		1	24604C
Probe	Probe top, plastic		1	24618D
	Probe bottom, plastic		1	24619D
	Digital Display		1	DD-1
	Probe window, plastic		1	24623A
	Probe board		1	PC-308
	Contact, Push-to-read		2	24549B
	Probe tip, metal		1	24605A
	Probe bracket		1	25190A
	Metalcal		1	MC-180
	Probe-tip bracket		1	24581A
	Screw, #4-40 x 3/8 Phil		1	obd
	Screw, #4-40 x 3/16 Phil		1	obd

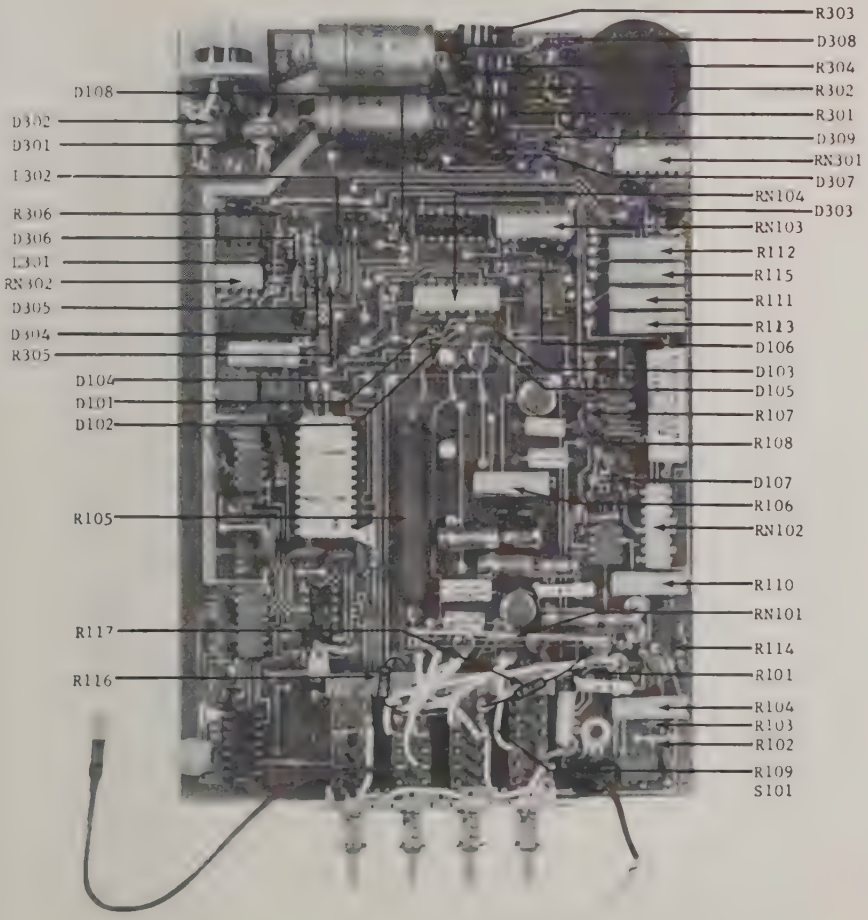


FIGURE 25. Component Layout, Resistors

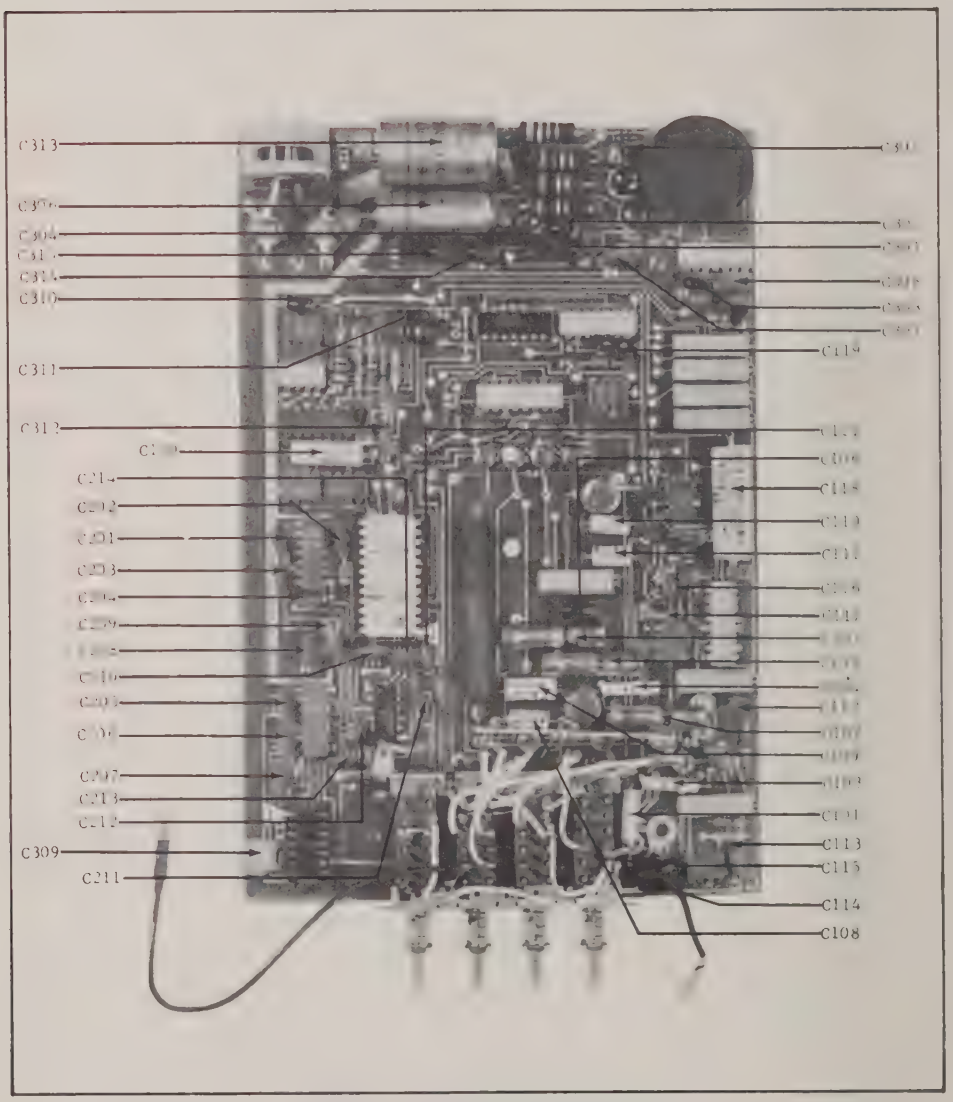


FIGURE 26. Component Layout, Capacitors.

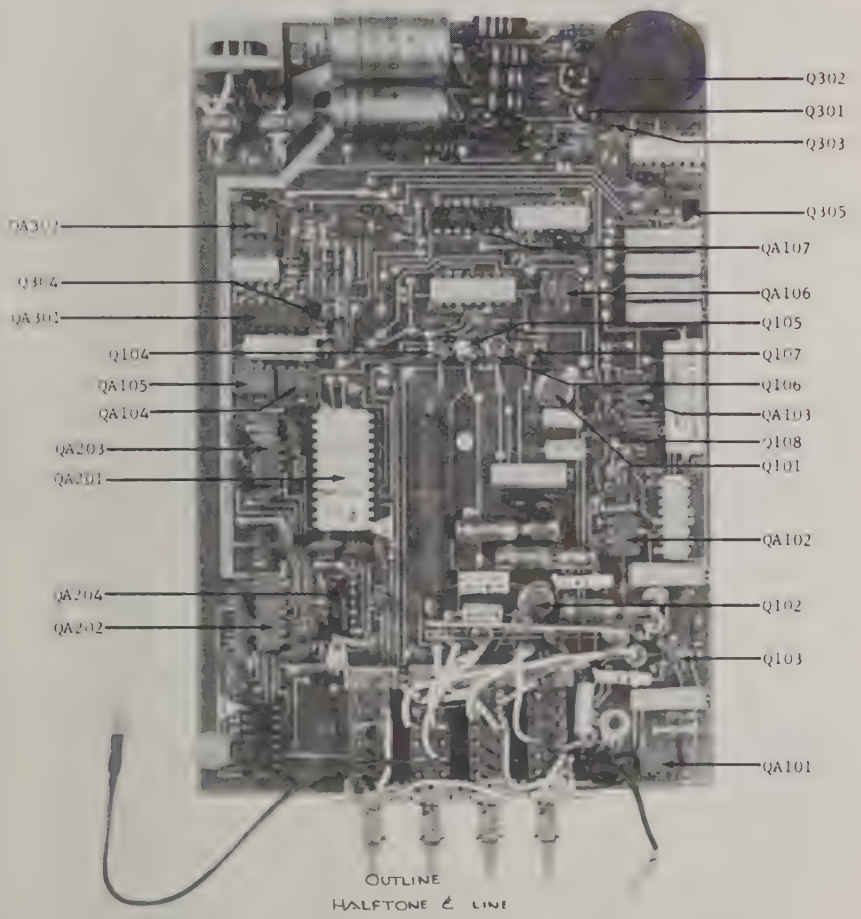


FIGURE 27. Component Layout, Transistors.

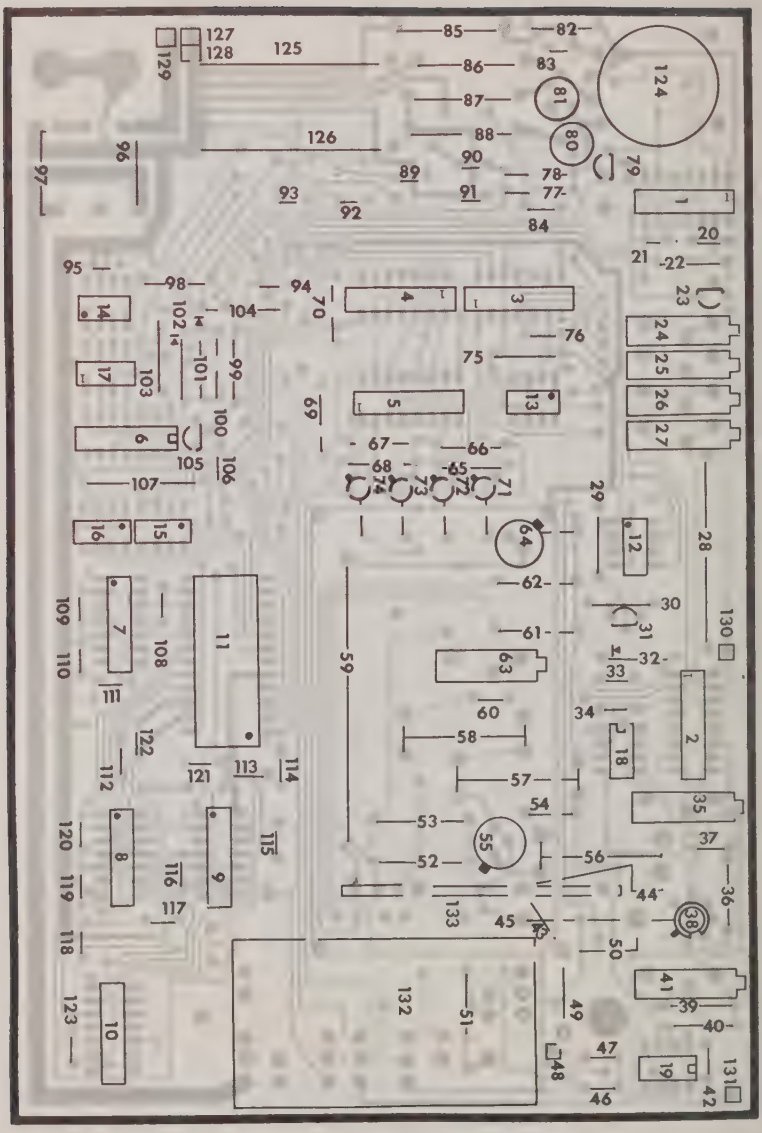
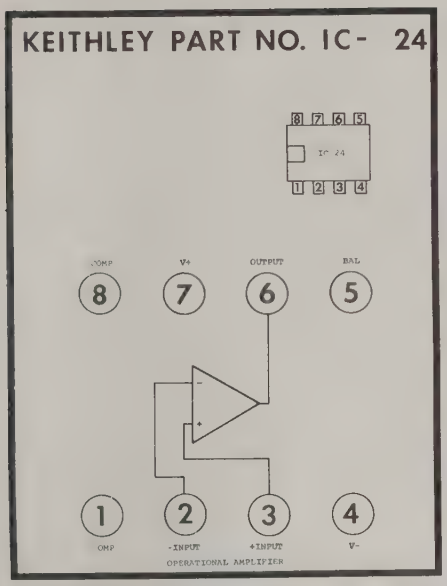
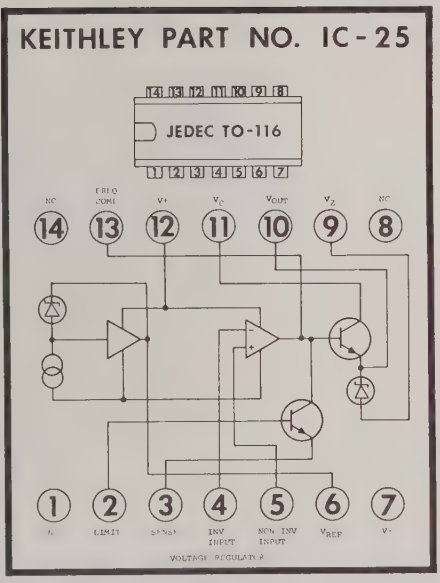
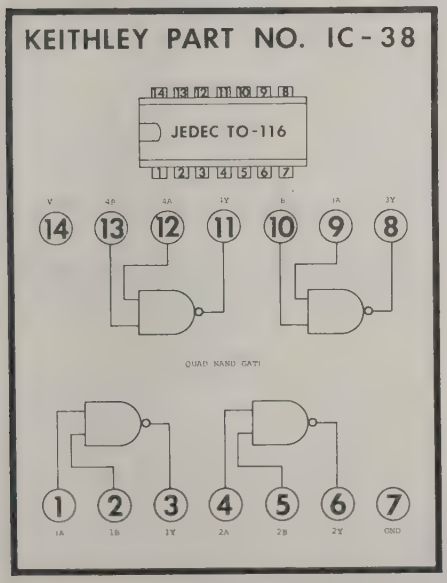


FIGURE 28. Printed Circuit PC-307.







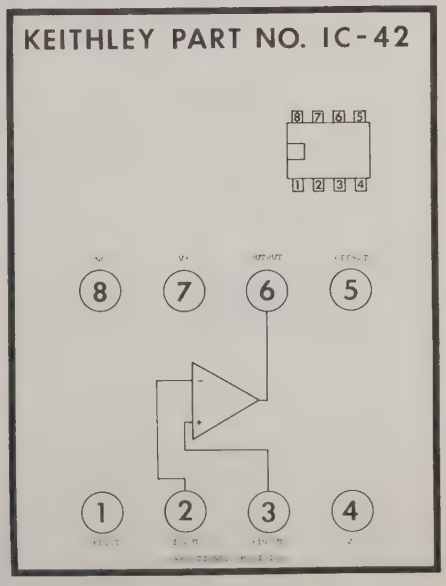
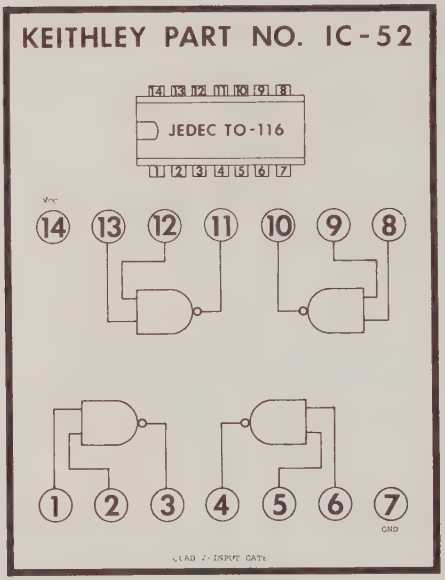
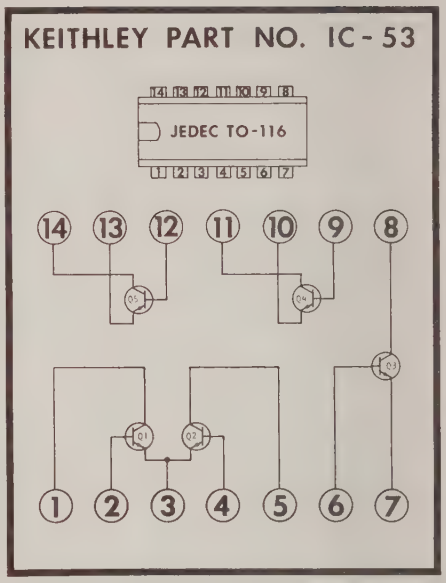
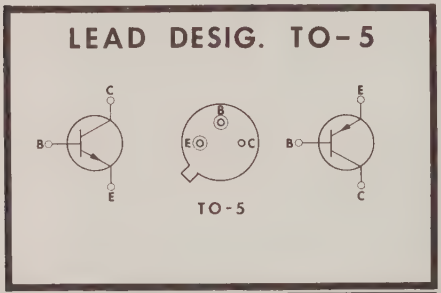
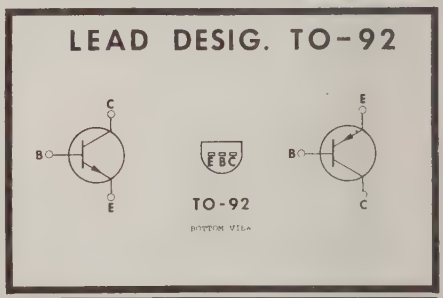


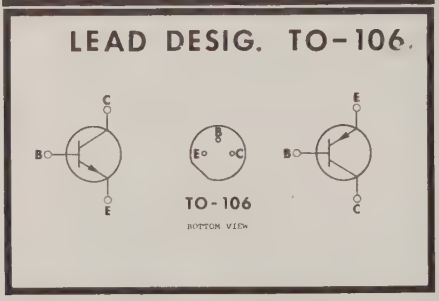
FIGURE 29. Case Outlines.

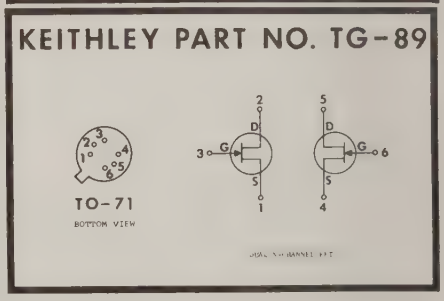




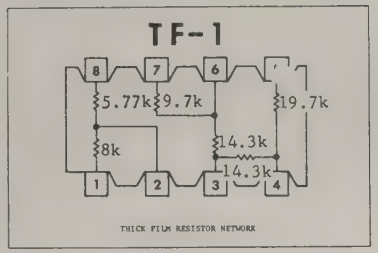


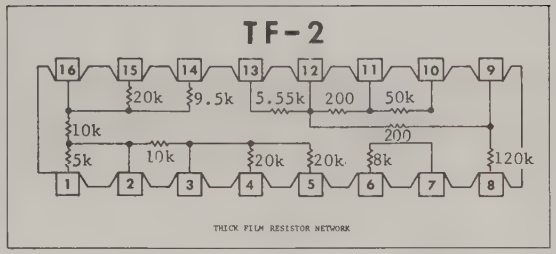


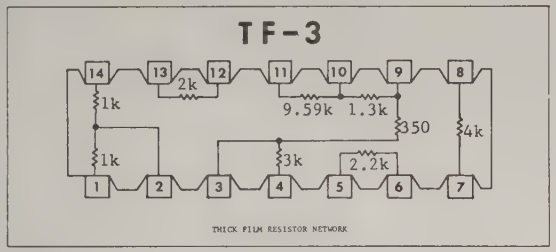


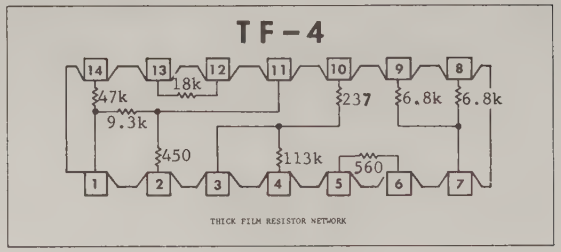


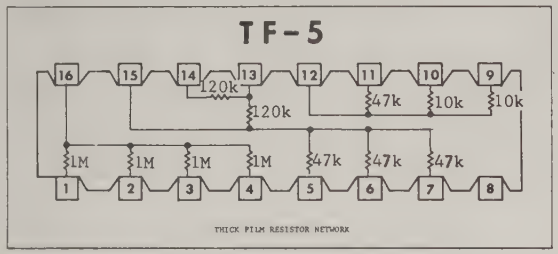
58 FIGURE 30. Case Outlines. 0172











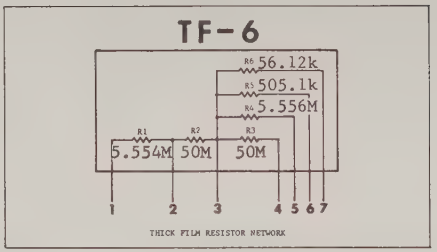


FIGURE 31. Case Outlines.

✓ See Change Notice

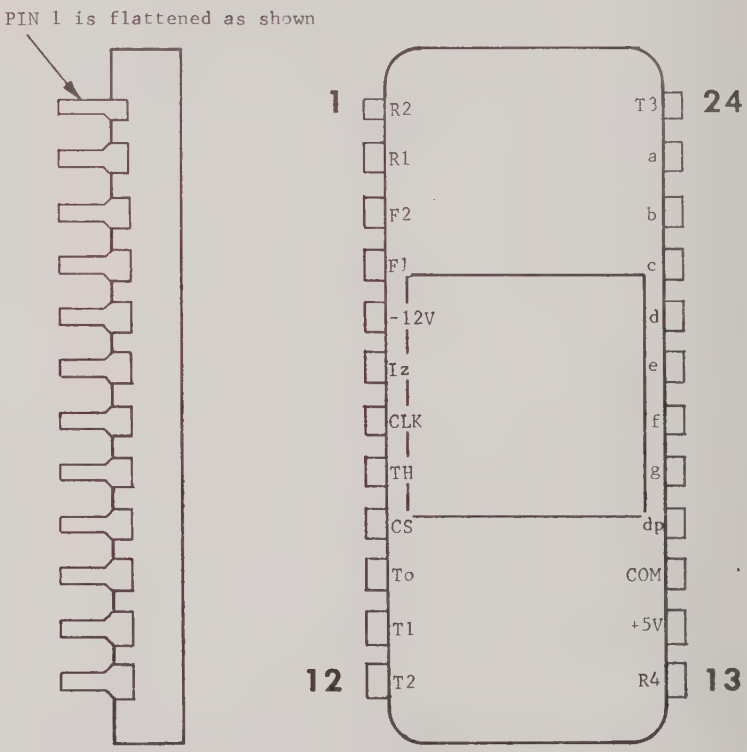


FIGURE 32. Case Outline, LSI-1.

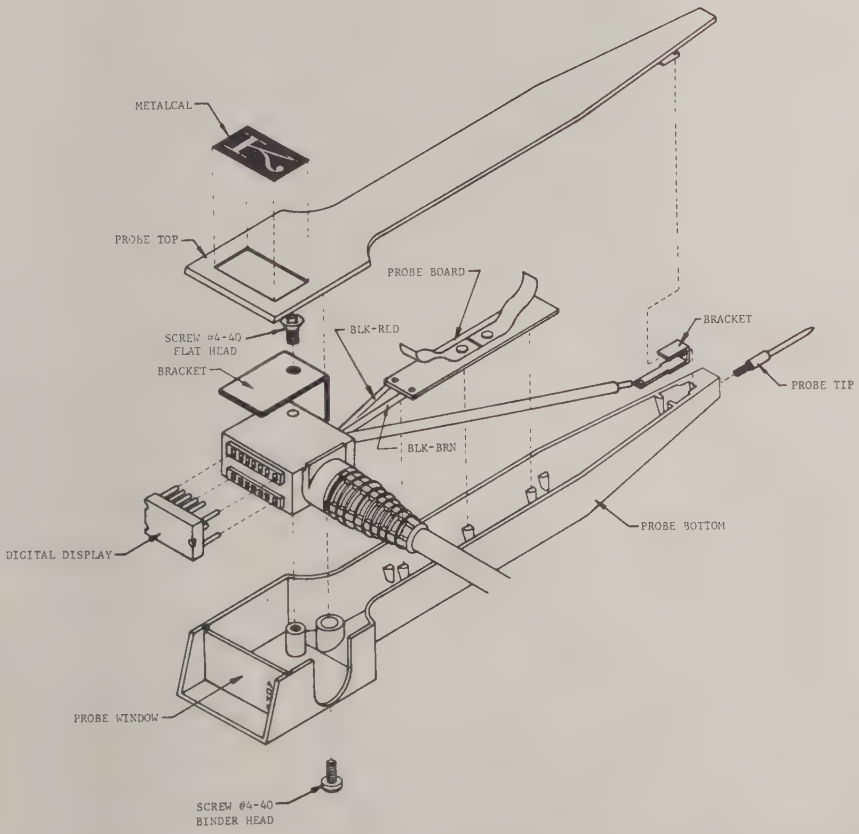


FIGURE 33. Probe Assembly

CODE—TO—NAME LIST

CODE TO NAME List of Suggested Manufacturers.
Reference: Federal Supply Code for Manufacturers, Cataloging Handbook H4-2.

00656 Aerovox Corp.
New Bedford, Mass. 02741

00686 Film Capacitors, Inc.
Passaic, N.J.

01121 Allen-Bradley Corp.
Milwaukee, Wisc. 53204

01295 Texas Instruments, Inc.
Semiconductor Div.
Dallas, Texas 75231

01686 RCL Electronics, Inc.
Manchester, N.H. 03102

02101 Varo Inc.
Electrokinetics Div.
Santa Barbara, Calif. 93102

02660 Amphenol Corp.
Broadview, Ill. 60153

02734 RCA
Defense Electronic Products
Camden, N.J.

02735 RCA
Receiving Tube Div.
Somerville, N.J.

02777 Hopkins Engineering Co.
San Fernando, Calif. 91342

02985 Tepro Electric Corp.
Rochester, N.Y. 14604

03508 General Electric Co.
Semiconductor Products
Syracuse, N.Y. 13201

04009 Arrow-Hart & Hegeman Elec.
Hartford, Conn. 06106

04713 Motorola Semicon. Prod.
Phoenix, Ariz. 85008

05079 Tansistor Electronics
Bennington, Vt. 05201

05397 Union Carbide Corp.
Electronics Div.
New York, N.Y. 10017

06751 Components, Inc.
Arizona Div.
Phoenix, Ariz. 85019

06980 Varian Assoc. EIMAC Div.
San Carlos, Calif. 94070

07137 Transistor Electronics Corp.
Minneapolis, Minn. 55424

07263 Fairchild Camera & Inst.
Mountain View, Calif.

07716 IRC, Inc.
Burlington, Iowa 52601

08811 GL Electronics Div.
GL Industries, Inc.
Westville, N.J. 08093

09052 Gulton Industries, Inc.
Alkaline Battery Div.
Metuchen, N.J.

09823 Burgess Battery Co.
Div. of Servel Inc.
Freeport, Ill.

09922 Burndy Corp.
Norwalk, Conn. 06852

10582 CTS of Asheville Inc.
Skyland, N.C.

11502 IRC Inc.
Boone, N.C. 28607

11534 Duncan Electronics, Inc.
Costa Mesa, Calif. 92626

11837 Electro Scientific Ind.
Portland, Or. 97229

12040 National Semiconductor Corp.
Danbury, Conn. 06813

12065 Transitron Electronic Corp.
East Boston, Mass.

12697 Clarostat Mfg. Co., Inc.
Dover, N.H. 03820

12954 Dickson Electronics Corp.
Scottsdale, Ariz.

13050 Potter Co.
Wesson, Miss. 39191

13327 Solitron Devices, Inc.
Tappan, N.Y. 10983

13934 Midwec Corp.
Oshkosh, Nebr. 69154

14655 Cornell-Dubilier Elec. Corp.
Newark, N.J.

14659 Sprague Electric Co.
Visalia, Calif. 93278

14752 Electro Cube Inc.
San Gabriel, Calif. 91776

15238 ITT Semiconductors
Div. of ITT Corp.
Lawrence, Mass. 01841

15909 Daven Div.
McGraw Edison Co.
Livingston, N.J.

16170 Teledyne Systems Co.
Communications Div.
Los Angeles, Calif. 90066

17554 Components, Inc.
Biddeford, Ma. 04005

17856 Siliconix Inc.
Sunnyvale, Calif. 94086

18324 Signetics Corp.
Sunnyvale, Calif. 94086

22525 Berg Electronics, Inc.
New Cumberland, Pa. 17070

23020 General Reed Co.
Metuchen, N.J. 08840

24655 General Radio Co.
West Concord, Mass. 01781

27682 Hathaway Instruments, Inc.
Denver, Colorado 80222

28520 Heyman Mfg. Co.
Kenilworth, N.J.

29309 Richey Electronics Inc.
Nashville, Tenn. 37213

32293 Intersil, Inc.
Cupertino, Calif. 95014

35529 Leeds and Northrup
Philadelphia, Pa. 19144

37942 Mallory, P. R. and Co.
Indianapolis, Ind. 46206

44655 Ohmite Mfg. Co.
Skokie, Ill. 60076

53201 Sangamo Electric Co.
Springfield, Ill. 62705

54294 Shallcross Mfg. Co.
Selma, N.C.

56289 Sprague Electric Co.
North Adams, Mass.

58474 Superior Electric Co.
Bristol, Conn. 06012

61637 Union Carbide Corp.
New York, N.Y. 10017

63060 Victoreen Instrument Co.
Cleveland, Ohio 44103

70309 Allied Control Co., Inc.
New York, N.Y.

70903 Belden Mfg. Co.
Chicago, Ill. 60644

71002 Birnbach Radio Co., Inc.
New York, N.Y.

71279 Cambridge Thermionic Corp.
Cambridge, Mass.

71400 Bussmann Mfg.
Div. of McGraw-Edison Co.
St. Louis, Mo.

71450 CTS Corp.
Elkhart, Ind.

71468 ITT Cannon Electric, Inc.
Los Angeles, Calif. 90031

71590 Centralab
Div. of Globe-Union, Inc.
Milwaukee, Wisc. 53212

71785 Cinch Mfg. Co.
Howard B. Jones Div.
Chicago, Ill. 60624

72259 Nytronics, Inc.
Pelham Manor, N.Y. 10803

72619 Dialight Corp.
Brooklyn, N.Y. 11237

72653 G-C Electronics Co.
Rockford, Ill. 61101

72699 General Instrument Corp.
Capacitor Division
Newark, N.J. 07104

72982 Erie Technological Prods.
Erie, Pa. 16512

73138 Beckman Instruments, Inc.
Helipot Division
Fullerton, Calif. 92634

73445 Amperex Electronic Div.,
North American Philips Co.
Hicksville, N.Y.

73690 Elco Resistor Co.
New York, N.Y.

74276 Signalite Inc.
Neptune, N.J. 07753

74970 Johnson, E.F., Co.
Waseca, Minn. 56093

75042 IRC Inc.
Philadelphia, Pa. 19108

75915 Littlefuse, Inc.
Des Plaines, Ill. 60016

76055 Mallory Controls Div.,
Mallory P. R. & Co., Inc.
Frankfort, Ind.

76493 Miller, J. W. Co.
Los Angeles, Calif. 90003

76545 Mueller Electric Co.
Cleveland, Ohio 44114

77764 Resistance Products Co.
Harrisburgh, Pa. 17104

79727 Continental-Wirt
Electronics Corp.
Philadelphia, Pa.

80164 Keithley Instruments, Inc.
Cleveland, Ohio 44139

80294 Bourns, Inc.
Riverside, Calif. 92506

81073 Grayhill, Inc.
La Grange, Ill. 60525

81483 International Rectifier
El Segundo, Calif.

82389 Switchcraft, Inc.
Chicago, Ill. 60630

83125 General Instrument Corp.
Capacitor Division
Darlington, S.C. 29532

83330 Smith, Herman H., Inc.
Brooklyn, N.Y. 11207

83594 Burroughs Corp.
Electronic Components Div.
Plainfield, N.J. 07061

83701 Electronic Devices, Inc.
Brooklyn, New York

84171 Arco Electronics, Inc.
Great Neck, N.Y. 11022

84411 TRW Capacitor Div.
Ogallala, Nebr.

84970 Sarkes Tarzian, Inc.
Bloomington, Ind.

86684 RCA
Electronic Components
Harrison, N.J.

87126 Philco Corp.
Lansdale Div.
Lansdale, Pa. 19446

90201 Mallory Capacitor
Indianapolis, Ind. 46206

90303 Mallory Battery Co.
Tarrytown, N.Y.

91637 Dale Electronics, Inc.
Columbus, Nebr. 68601

91662 Elco Corp.
Willow Grove, Pa.

91737 Gremar Mfg. Co., Inc.
Wakefield, Mass.

91802 Industrial Devices Inc.
Edgewater, N.J. 07020

91929 Honeywell Inc.
Micro Switch Div.
Freeport, Ill. 61032

93332 Sylvania Electric Prod.
Semiconductor Prod. Div.
Woburn, Mass.

93656 Electric Cord Co.
Caldwell, N.J.

94144 Raytheon Co., Industrial
Operation Components Div.
Quincy, Mass.

94154 Tung-Sol Electric, Inc.
Newark, New Jersey

94310 Tru-Ohm Products
Memcor Components Div.
Huntington, Ind. 46750

94696 Magnecraft Electric Co.
Chicago, Ill.

95263 Leecraft Mfg. Co., Inc.
L.I. City, N.Y. 11101

95348 Gordos Corp.
Bloomfield, N.J. 07003

95712 Dage Electric Co., Inc.
Franklin, Ind.

97419 Standard Condenser Co.
Chicago, Ill. 60613

97933 Raytheon Co. Components Div.
Semiconductor Operation
Mountain View, Calif.

99120 Plastic Capacitors, Inc.
Chicago, Ill.

SECTION 7. SCHEMATIC DIAGRAMS

7-1. GENERAL. The schematic diagrams which describe the circuitry of the Model 167 are arranged in four separate diagrams as follows:

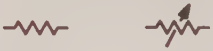
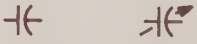
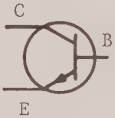
a. Block Diagram, No. 25354D. This diagram shows the interconnections between the probe display as well as the relationship of the major circuits. The regulated power supply is shown on Schematic No. 25340D. The LSI chip and display drivers are shown on Schematic 25343D.

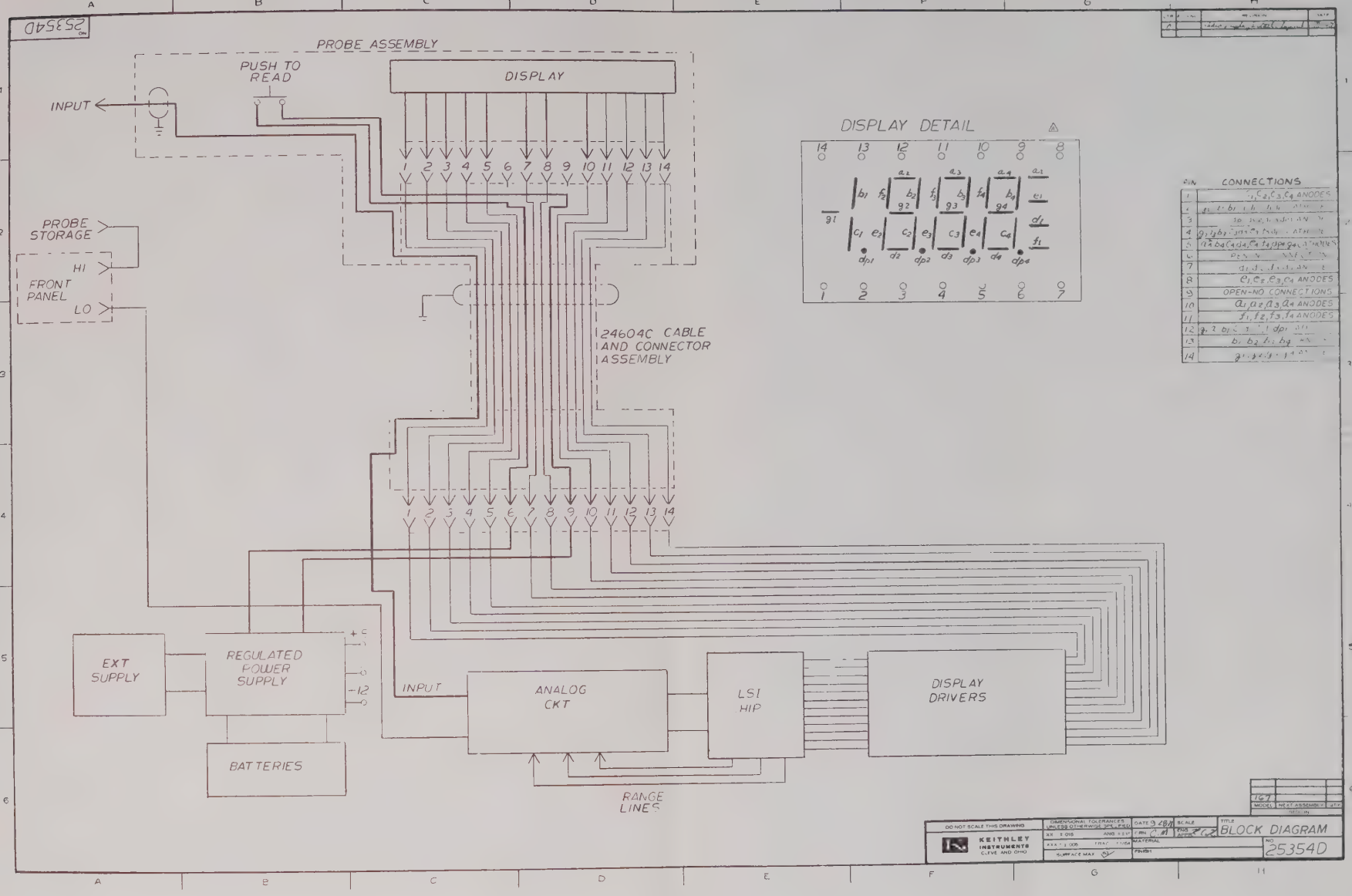
b. Power System, No. 25340D. This diagram shows the circuitry used in the regulated power supply including the Auxiliary Power connections and battery supply. The "Push-to-Read" switch is shown on Block Diagram, No. 25354D.

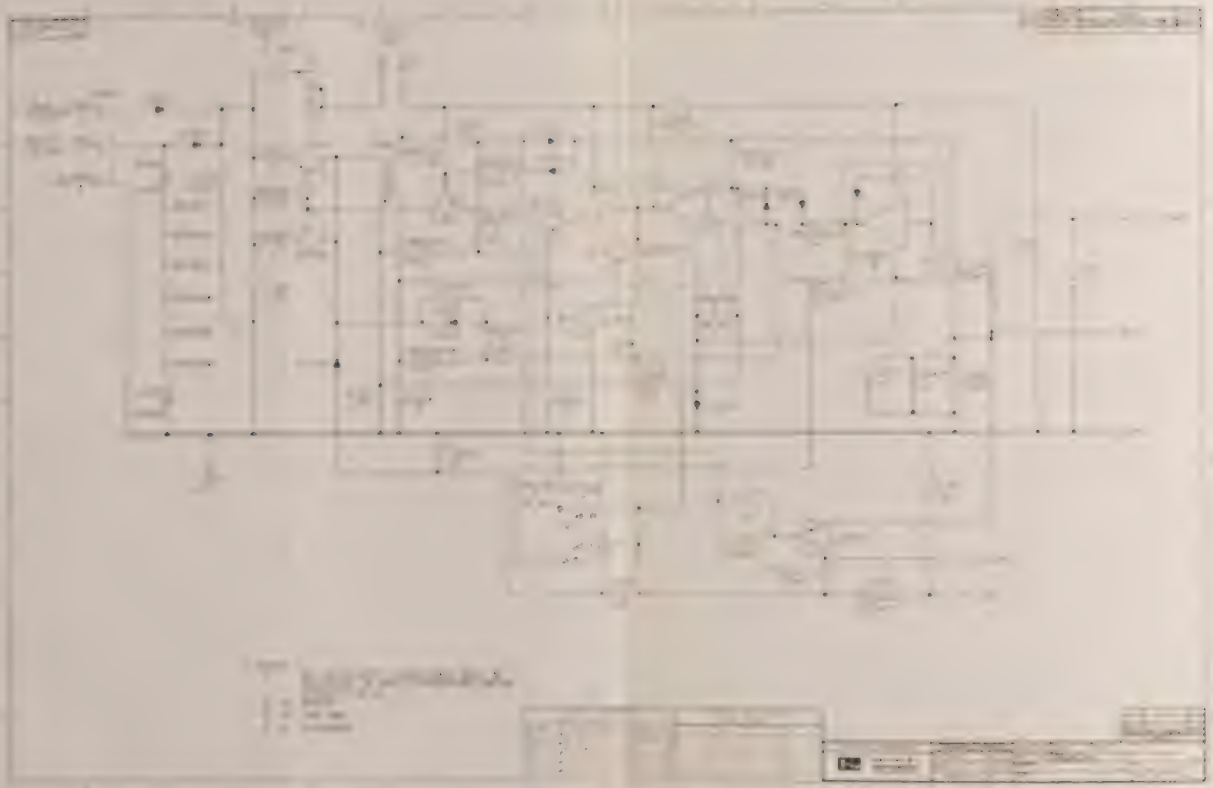
c. Analog Circuit, No. 25342D. This diagram shows the circuitry used in the analog amplifier and range switching. To fully understand the operation of the analog-to-digital converter and the automatic ranging circuitry refer to pages 20, 21, and 22 for identification of the LSI inputs and outputs.

d. Digital Circuitry, No. 25343D. This diagram shows the interconnections between the LSI (QA201) and the display drivers. The internal circuitry of the Large Scale Integrated Circuit (LSI) is Keithley proprietary information and is not shown on any of the schematic diagrams. A discussion of the LSI operation is given in Section 4 of the instruction manual.

TABLE 7-1.
Symbols Used On Schematic Diagrams

Symbol	Description
	resistor, fixed or variable
	capacitor, fixed or variable
	diode, pn-junction
	diode, zener reference
	inductor, fixed
	transformer, fixed
	amplifier, integrated circuit type
	transistor, npn-type
	battery, single cell
	transistor, field-effect (FET) n-type
	logic gate, NAND type
	chassis common or LO
	internal screwdriver adjustment
	plug and jack connection
	switch, normally-open type


PROBE ASSEMBLY
PUSH TO READ
DISPLAY
INPUT
PROBE STORAGE
HI
FRONT PANEL
LO
24604C CABLE AND CONNECTOR ASSEMBLY
DISPLAY DETAIL
CONNECTIONS
EXT SUPPLY
REGULATED POWER SUPPLY
+5
0
-12
INPUT
ANALOG CKT
LSI HIP
DISPLAY DRIVERS
BATTERIES
RANGE LINES
DO NOT SCALE THIS DRAWING
KEITHLEY INSTRUMENTS
CLEVE AND OHIO
BLOCK DIAGRAM
25354D



SERVICE FORM

ODEL 167
ERIAL NO. _____

R-

HIP INSTRUMENT & FORM TO:

ALES SERVICE DEPT.
EITHLEY INSTRUMENTS, INC.
3775 AURORA ROAD
LEVELAND, OHIO 44139

FROM:

USER'S NAME _____
RETURN ADDRESS _____
_____
CITY _____
STATE _____ ZIP _____

. DESCRIPTION OF PROBLEM OR DEFICIENCY.

. OPERATING CONDITIONS. Check appropriate box.

☐ Alkaline batteries installed.
☐ Rechargeable Nickel-Cadmium batteries installed.
  ☐ Model 1671 Recharger utilized.
☐ Line operation using Model 1672.
  ☐ 117V
  ☐ 234V
☐ External power source used. Voltage level used is _____.
  Ambient Temperature _____
  Humidity _____

. ADDITIONAL INFORMATION. Please indicate any other pertinent information hich may help the Keithley Repair and Calibration Dept.

ho should we contact for more information?

ame _____
itle _____
ept. _____
elephone _____

KEITHLEY INSTRUMENTS, INC.

28775 AURORA ROAD • CLEVELAND, OHIO 44139 • (216) 248-0400
TELEX: 98-5469 • CABLE: KEITHLEY